MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY,

CONTAINING

PAPERS, ABSTRACTS OF PAPERS, AND

REPORTS OF THE PROCEEDINGS

OF THE SOCIETY

FROM NOVEMBER 1889 *TO NOVEMBER* 1890.

VOL. L.

LONDON:
ROYAL ASTRONOMICAL SOCIETY,
BURLINGTON HOUSE, W.
1890.

PRINTED BY
SPOTTISWOODE AND CO., NEW-STREET SQUARE
LONDON

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. L. NOVEMBER 8, 1889. No. 1

W. H. M. CHRISTIE, M.A., F.R.S., President, in the Chair.

Richard Evan Day, M.A., 135 Fellows Road, Hampstead, N.W.;
Philip F. Duke, Hendon, Middlesex;
The Rev. Thomas Jones, B.A., LL.D., Curdworth Rectory, Birmingham,

were balloted for and duly elected Fellows of the Society.

S. C. Chandler, Harvard College, Cambridge, Mass., U.S.A.;
N. C. Dunér, Director of the Observatory, Upsala, Sweden;
Paul Henry, Astronome à l'Observatoire, Paris;
Prosper Henry, Astronome à l'Observatoire, Paris,

were balloted for and duly elected Associates of the Society.

The following candidates were proposed as Fellows of the Society, the name of the proposer from personal knowledge being appended:—

Albert Fowell Austin, Schoolmaster, Luton, Bedfordshire (proposed by Alfred F. Smith);
Algernon Sidney Bicknell, Staplefield Place, Crawley, Sussex (proposed by A. A. Common);
The Rev. George Burgess, The Woodlands, Urmston, Manchester (proposed by the Rev. J. Burgess);
Démétrius Eginitis, D. ès Sc., Astronome à l'Observatoire de Paris (proposed by A. Cowper Ranyard);
George Richard Farncombe, M.A., Green Hill, Handsworth, near Birmingham (proposed by Sir R. S. Ball);
Vernon Edwin Knocker, Solicitor, Castle Hill House, Dover (proposed by Edmund J. Spitta);

Benjamin Noble, Gloucester House, Newcastle-on-Tyne (proposed by A. Cowper Ranyard);
Henry William Lloyd Tanner, M.A., The Abbotts, Clive Road, Penarth, Cardiff (proposed by Sir James Cockle);
R. Lethbridge Tapscott, Owen's College, Manchester (proposed by the Rev. C. R. Gordon);
William Grasett Thackeray, Royal Observatory, Greenwich (proposed by W. H. M. Christie).

Report of the Eclipse Committee of the Royal Astronomical Society, 1889 *October* 3. Drawn up by H. H. Turner, Secretary to the Committee.

The preparations which have been made since the last meeting of the Committee for observing the Total Solar Eclipse of 1889, December 21–22, are summarised in the following report:—

1. Application was made by the Secretary of the Royal Astronomical Society to the Government Grant Committee of the Royal Society for a sum of 400*l.* for the observation of this eclipse. This application was granted. A sum of 120*l.* has since been paid to Mr. A. A. Common for the mounting of two silver-on-glass mirrors of 20-inch aperture and 45-inch focus, to be used on these expeditions. The mountings are thus the property of the Royal Society by the terms of their grant; and to complete the instruments Mr. Common will present the mirrors to that Society, so that by an expenditure of 120*l.* alone two first-class instruments, of whose excellence more will be said hereafter, will be acquired for eclipse and other work.

Sums of 100*l.* and 120*l.* have also been paid to the observers, the Rev. S. J. Perry and Mr. A. Taylor respectively, for their expenses on the expedition. Mr. Taylor will necessarily make a longer stay at his station, and his journey will be more expensive. The remaining 60*l.* is still in the bank, and will be available for contingencies.

2. On application by the Secretary of this Committee, Messrs. Elder, Dempster & Co., the proprietors of the line of steamers by which Mr. Taylor reaches Loanda, have generously consented to convey him at half the usual fare.

A similar application has been made to the Royal Mail Steamship Company, by whose line the Rev. S. J. Perry reaches Barbados; and the directors have similarly consented to convey him and his assistant to the West Indies for 35*l.* each return fare.

3. Application was made by the Secretary of the Society to the Admiralty for assistance at each of the stations, and the Admiralty have given directions that a vessel should be at the

disposal of each of the observers during the eclipse; and moreover that the one should convey the Rev. S. J. Perry from Barbados to a suitable station on the Salut Isles (on which he has finally decided as the best position), and on the return voyage; and similarly the other should convey Mr. Taylor from Loanda to the station which he may select on the coast, and return with him to Loanda after the eclipse.

4. On application by the Secretary of the Society the Foreign Office has obtained facilities from the French and Portuguese Governments respectively for the expeditious landing of the observers at their respective stations.

5. As regards instrumental equipment:—

A. Captain Abney has lent to the expeditions the two lenses of 4-inch aperture and 5-foot focus, which have previously been used in Egypt (1882), Caroline Island (1883), and Grenada (1886), and one of which was taken to Russia (1887) but without result. Each observer will take one of these lenses.

The mountings for these are—

(1) A portable mounting made by Messrs. Troughton & Simms for Mr. Maunder's use in 1886 (Grenada), and taken to Russia (1887) by Father Perry.

(2) A photo-heliograph mounting used by Dr. Schuster in 1886 (Grenada), and since used by Captain Abney at South Kensington.

(1) is the property of the Royal Society, and (2) belongs to the Royal Observatory, Greenwich.

B. Mr. Common has constructed two silver-on-glass mirrors of 20-inch aperture and 45-inch focus for photographing the corona. The mountings have been made from his design, and purchased with part of the special grant for this eclipse (see paragraph 1). Each observer will take one of these mirrors.

C. A 4-inch theodolite and some tools, the property of the Royal Society, and used in the eclipse expedition of 1886, and a prismatic compass, belonging to the Royal Observatory, Greenwich, have been lent to Mr. Taylor.

D. Application has been made to the Admiralty for the use of two chronometers, and they have granted the use of Arnold 590 (one day), and M'Cabe 133 (one day).

6. *The objects of the expeditions* are threefold:—

I. To detect any possible changes in the corona during the two hours and a half that elapse between totality at the respective stations.

II. To photograph the coronal extension as far as possible.

III. To determine the photometric intensity of the corona.

Both the pairs of instruments (lenses and mirrors) are available for I.; the mirrors were specially designed for II.; both pairs of instruments would be available for III., but for simplification of the programme the mirrors will not be used in this connection.

As regards object I., the similarity of the instruments has been secured in each case. The atmospheric and astronomical conditions will be somewhat different at the two stations, but by varying the exposure it is hoped to get virtually similar photographs at the two ends of the line.

As regards II., it is generally known that eye observations have traced coronal or quasi-coronal light to immense distances from the Moon's limb, especially when the atmospheric absorption is small (as at great heights), and when care is taken to render the eye sensitive before totality. But it is doubtful whether this extension has been photographed; and eminent photographers consider that there is evidence for the supposed extension being simply diffused light from the sky, and not corona at all. The failure of exposures of say three minutes to give sensibly greater extension than one minute is adduced by Captain Abney as a reason for believing the evidence to be on the whole against the reality of coronal streamers. But it must be remembered that it is only quite recently that photographic objectives of more than a few inches aperture have been employed in eclipse work; and the failure to impress the photographic plate may be simply an indication of the feebleness of the light. With the view of attempting to settle this question, Mr. Common has constructed two mirrors which far out-distance in light-grasping power anything previously available for such work. The aperture of each is 20 inches, and the focal length is 45 inches, which, with full aperture, would give a ratio of 1 : $2\frac{1}{4}$; but there is an internal diaphragm, aperture 15 inches, placed at $\frac{1}{3}$ the focal length within the focus, which reduces the ratio of effective aperture and focal length to 1 : 3. The advantages gained by this internal diaphragm as regards definition at some distance from the centre of the field are pointed out by General Tennant in *Monthly Notices*, vol. xlvii. p. 244.

It does not seem likely that more favourable instrumental conditions can well be devised, with modern methods, for photographing a faint object such as the outer corona; and even if the result be negative it will therefore be of some value. The chief point to be attended to in the use of the mirrors is thus to get long-exposure pictures. Short exposures will also be of interest, but the question the mirrors were built to settle is the reality of the coronal extension.

As regards III., Captain Abney read a paper to the Royal Astronomical Society in 1889, March (*Monthly Notices*, vol. xlix. p. 285), suggesting that the plates taken out by the observers should be fitted with standard squares such as he had described to the Photographic Society in 1885, and which have since been

used by American observers in 1886 and 1889, January 1. Captain Abney has kindly consented to make plates for the expeditions, and put on the squares himself. Each plate will then be available for determining the photometric intensity at any point of the corona which appears on it.

7. The following instructions to the observers have been drawn up for approval by the present Committee :—

(*a*) Packing cases to be reclosed as far as possible, and protected from the weather and damage. Care to be taken not to damage tin cases.

(*b*) For as many days as possible before the eclipse all the instruments to be arranged as during the eclipse, and complete rehearsals of all the operations intended to be made during the eclipse to be most rigidly carried out.

(*c*) A statement of the days on which these rehearsals have been made to be given in the report of the operations. A daily note-book to be kept, and no notes destroyed.

(*d*) Approximate latitude and longitude of station to be determined and noted, and chronometer rated by any practicable means. (The naval officers will probably do this with sextant.)

(*e*) Instruments to be focussed, and trial-plates taken, if possible, at least two days before totality. These trial plates to be carefully preserved. For the mirrors the focus should be adjusted, not for the centre of the plate, but for a region about $\frac{3}{4}^\circ$ from centre. This must be determined by star photographs.

(*f*) Special attention to be given to the rating of the clocks at least three days before eclipse. Notes of rates to be carefully preserved.

(*g*) A quarter of an hour before totality clocks to be wound, and caps and stops, which had been hitherto used to diminish the amount of light, to be removed if necessary.

(*h*) The actual method in which time is to be called is left to the observer, but the timekeepers should be thoroughly and carefully drilled, and their counting should be in a loud voice.

(*i*) There should also be, if possible, three recorders, whose business it will be to enter *independently* the exact second called by the timekeeper when each plate is exposed, and when the exposure is complete. The notes of each to be handed over to the observer without comparison *inter se*, and compared by him as soon as convenient after the eclipse; these records on no account to be altered, but notes of suggested alterations to be made.

(*k*) There should also be a person specially detailed to give out the plates in order. After exposure they should be immediately placed in the receiving dark chamber.

(*l*) At the Salut Isles, Father Perry will take complete charge of the mirror, and Mr. Rooney (under his direction) of the lens.

At the African station, Mr. Taylor will take charge of the

lens, and will entrust the mirror to the most capable person available, who shall be under Mr. Taylor's supervision before and after totality, but shall act entirely independently during totality.

(*m*) The following plates are to be exposed :—

With the Lenses.

Mr. Rooney.		Mr. Taylor.
With 1-inch diaphragm	4 secs. (=¼ sec. full) ...	4 secs. (=¼ sec. full)
	8 „ (=½ sec. full) ...	8 „ (=½ sec. full)
Full aperture	1 sec.	1 sec.
	5 secs.	5 secs.
	15 „	15 „
	40 „	40 „
	Sum = 93 secs.	70 „
	Totality = 135 „	Sum = 163 secs.
	Two at discretion.	Totality = 186 „
	(2 secs. or 5 secs. suggested.)	One at discretion.

With the Mirrors.

Father Perry.		Mr. Taylor's assistant.	
1 sec.		1 sec.	
5 secs.		5 secs.	
10 „	= 76 secs.	10 „	= 76 secs.
20 „	Totality = 135 „	20 „	Totality = 186 „
40 „		40 „	
Others at discretion.		Others at discretion.	

(*n*) The plates left to discretion at the end of each series should be developed as soon as possible, as experience with trial plates may suggest. If the development is successful, *and these plates are successfully copied*, the other plates should be developed and copied, but on no account is the development of the earlier plates to be commenced until successful copies are made of the discretionary plates.

Such copies are to be deposited with the most trustworthy person available, to be sent home afterwards on application by the observer.

The pictures should not be overdeveloped, certainly not beyond the point when the densest part of the image can just be seen through the back of the plate.

The two or three developers tried by the observers in England to be thoroughly tested by trial plates before the eclipse. The following is suggested by Captain Abney :—

1. Pyrogallic acid	...	2 grains	No. 1 ... ½ oz.
Water ...	...	½ oz.	2 ... 2 drs.
2. Bromide potass	...	20 grains	3 ... 30 min.
Water ...	...	1 oz.	4 ... 2 dr.
3. Ammonia (·880)	...	1 part	Add water up to 2 oz.
Water ...	...	9 parts	
4. Sulphite of soda, a saturated solution			

(*o*) Careful attention to be paid to the orientation of the plates with both instruments by taking photographs of the Sun (with pin-hole apertures) with the telescope clamped (*clock not driving*), at intervals of one hundred seconds on the same plate—so that the images overlap —on the days before and after the eclipse, at the local time at which the eclipse takes place.

(*p*) The plates available for use with the mirrors, in addition to those exposed during totality, are to be *exposed after totality*, viz. up to three minutes after totality ends at regular intervals, according to the number of plates at disposal. These plates are designed to determine how long the limb of the Moon is visible against the corona. Eye observations may also be made of this phenomenon by competent observers, but not by the photographers themselves.

(*q*) Any other observations or drawings which the observers may superintend are to be so arranged that there shall be no possible interruption of the photographers during the half hour including totality.

8. The instruments have been examined by the observers, and are now all ready for the expedition. The Rev. S. J. Perry has taken several photographs with the 4-inch lens (and previously with a 6-inch lens), to thoroughly test the driving of the clock. He has visited Ealing twice, and examined the mounting and working of the mirrors with Mr. Common.

Mr. Taylor's instruments are already packed for transport. He has taken several photographs with one of the mirrors : notably of the Earth-shine on the crescent Moon—exposure, 3 minutes (the crescent being burnt out); of the nebulæ in the *Pleiades*—exposure, 30 minutes. The definition is good up to half a degree from the centre, and fair beyond that point.

9. This report would be incomplete without an express reference to the generous assistance the expeditions have received from Captain Abney and Mr. Common. The names of these

gentlemen have already been mentioned in several connections; but Mr. Common especially has given a great deal of time and attention to the numerous matters connected with the expeditions; and this kindly assistance will have contributed in no small degree to any success which the expeditions may meet with.

10. The following details as to other stations and observers may be of interest:—

(1) Mr. G. C. Bruce, the meteorological officer at St. Helena, wrote to the Astronomer-Royal, offering, on behalf of His Excellency the Governor, every assistance to any expedition which might be sent out. He was informed that the central line passed about 2° 50′ N. of St. Helena, and that station was not therefore to be occupied.

(2) Professor Holden, of the Lick Observatory, wrote informing the Secretary of the Society that two of his assistants were to proceed to some point in South America for observation of the eclipse, and asking for information as to the movements of our observers. He was informed by the Secretary of this Committee of the general plans of operation, as far as they were then developed.

(3) Mr. J. P. Smith has made inquiries about the voyage to Cayenne, and was referred to the Rev. S. J. Perry.

(4) Information has been received that Miss E. Brown and Miss Jefferies are proceeding to Trinidad to observe the eclipse.

(5) From *Nature*, for 1889, Sept. 12, we learn that the Navy Department in Washington is fitting out an expedition to Muxima, in Angola, about one hundred miles in the interior up the Coanza river. The party will be a large one, under the direction of Professor D. P. Todd, and will remain some time at the station.

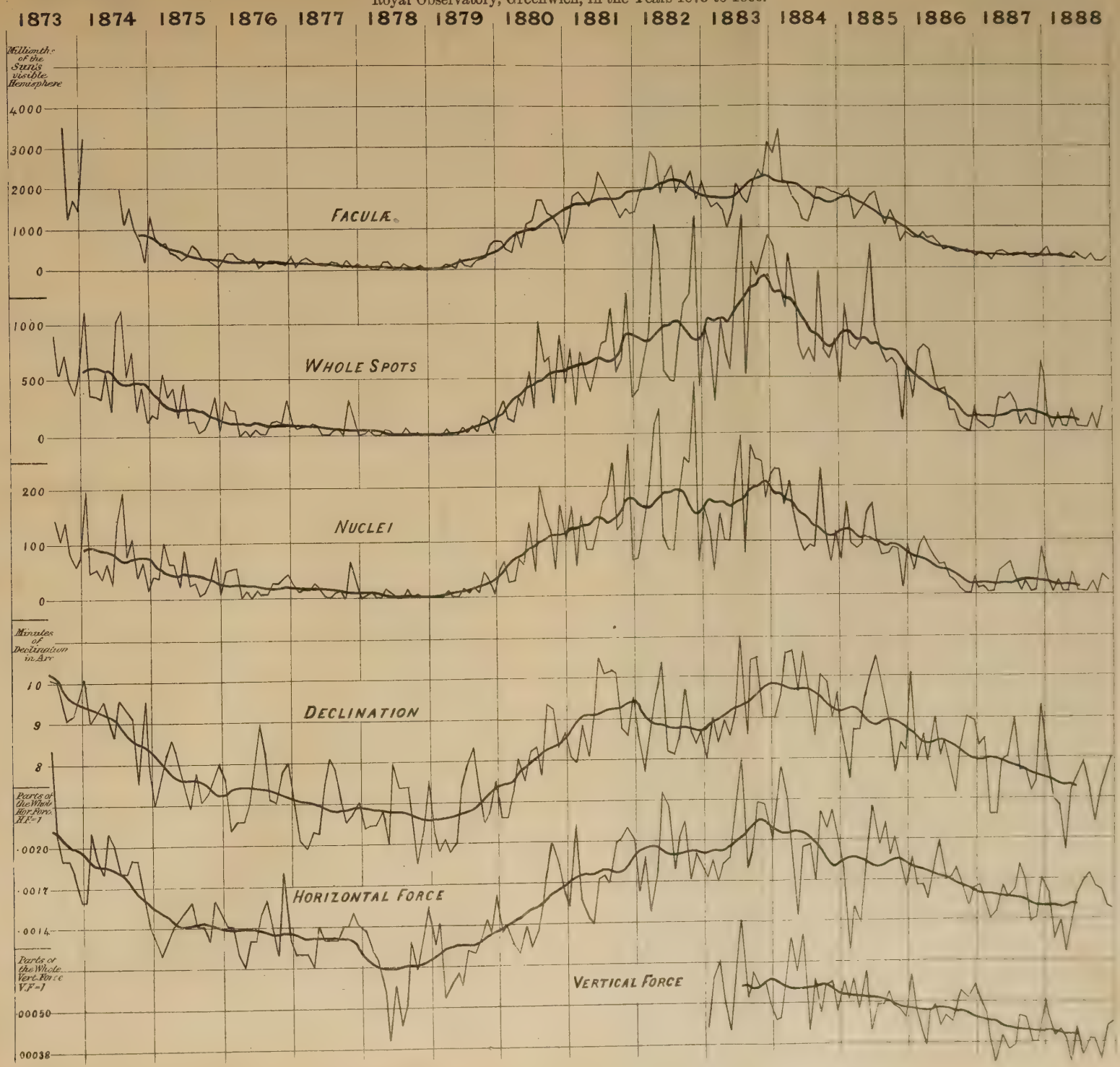
(6) Professor Tacchini has applied to the Committee for leave to join the Rev. S. J. Perry in his expedition to the Salut Isles. [October 18. Professor Tacchini has unfortunately been prevented from joining the expedition.]

Areas of Faculæ and Sun-spots, compared with Diurnal Ranges of Magnetic Declination, Horizontal Force, and Vertical Force, as observed at the Royal Observatory, Greenwich, in the Years 1873 *to* 1888.

(*Communicated by the Astronomer Royal.*)

The three upper curves of Plate I., representing the areas of faculæ, whole spots, and umbræ respectively, exhibit in a graphical form the results given on pages 106, 107, and 108 of

Areas of Faculæ, Whole Spots, and Nuclei, compared with Diurnal Ranges of Magnetic Declination, Horizontal Force, and Vertical Force, as observed at the Royal Observatory, Greenwich, in the Years 1873 to 1888.



the *Greenwich Spectroscopic and Photographic Results* for 1884, and in similar tables in the volumes for the succeeding years. The mean areas for each of the three orders of solar markings have been formed by taking the means of the areas as measured upon the solar photographs, corrected for foreshortening, and reduced to millionths of the Sun's visible hemisphere, for each day of observation throughout each synodic rotation of the Sun. The commencement of each rotation is defined by the coincidence of the assumed prime meridian with the central meridian, the assumed prime meridian being that meridian which passed through the ascending node at mean noon on 1854, January 1, and the assumed period of the Sun's sidereal rotation being 25·38 days.

The ordinates for the three curves represent, therefore, the mean daily areas for each synodic rotation expressed in millionths of the Sun's visible hemisphere. The scale on which the ordinates have been drawn is five times as large for the nuclei as for the whole spots, and three and one-third times as large for the whole spots as for the faculæ, in order that the variations in each curve might be equally distinct; for the areas of the whole spots are, on the average, about five times as great as those of the nuclei, and of the faculæ about three times as large as of the whole spots. A smooth curve has also been drawn for each of the three orders of phenomena, the ordinates for which correspond at any given rotation to the mean of the areas for thirteen rotations, or of a year very nearly, i.e. the mean of the areas for the rotation in question, for the six rotations immediately preceding it, and for the six immediately following it.

From 1873 to the end of 1881 only the photographs taken at the Royal Observatory, Greenwich, were available for measurement, but from 1881 December 21 the gaps in the Greenwich series have been filled as far as possible by photographs taken at Dehra Dûn, India; and from the beginning of 1885 by photographs taken at the Royal Alfred Observatory, Mauritius, as well. The daily record for the years 1882 to 1888 may, therefore, be considered as practically complete.

In explanation of the construction of the magnetic curves it may be mentioned that the annual volumes of Greenwich observations contain tables, giving for each of the magnetic elements of declination, horizontal force, and vertical force, its mean value at each hour in every month. The difference between the greatest and least of these hourly values in every month is the monthly diurnal range. The values for vertical force are not available until the year 1883, in consequence of difficulty with the temperature correction. The results, both for horizontal force and for vertical force, are corrected for temperature. Now the magnetic diurnal ranges are subject to an annual period, being greatest in summer and least in winter, the period being one which, depending on geographical position, has not necessarily any counterpart in the solar spot variation, and which,

therefore, should be eliminated in order to make comparison with the Sun-spot curves. The mean monthly value of diurnal range having been found from the results for the years 1841 to 1877 for declination and horizontal force, and from the results for 1883 to 1888 for vertical force, the differences in each case between the several mean monthly values and the mean yearly value give corrections which, applied to the monthly values for any individual year, clear out the average annual inequality, leaving only the accidental irregularity remaining. In this way the irregular-looking curves of diurnal range of magnetic declination, horizontal force, and vertical force given in the plate are found.

The smoothed curves are formed as follows:—Assuming equality in the length of the several calendar months in each element, the mean of the first twelve values is taken, then the mean of the second to the thirteenth value, the mean of the third to the fourteenth value, and so on. Finally, the mean of each adjacent pair of the means so formed is taken, from which resulting values the smoothed curve is formed.

The declination range is given in angular measure, and those of horizontal force and vertical force in parts of the whole horizontal and vertical forces respectively, the scales being so arranged that equal changes of absolute magnetic force are represented by an equal length of ordinate. 1′ of declination corresponds to ·0003 of horizontal force, and to $\frac{\cdot 0003}{\tan \text{dip}} = \cdot 00012$ of vertical force, the values adopted in setting out the various scales.

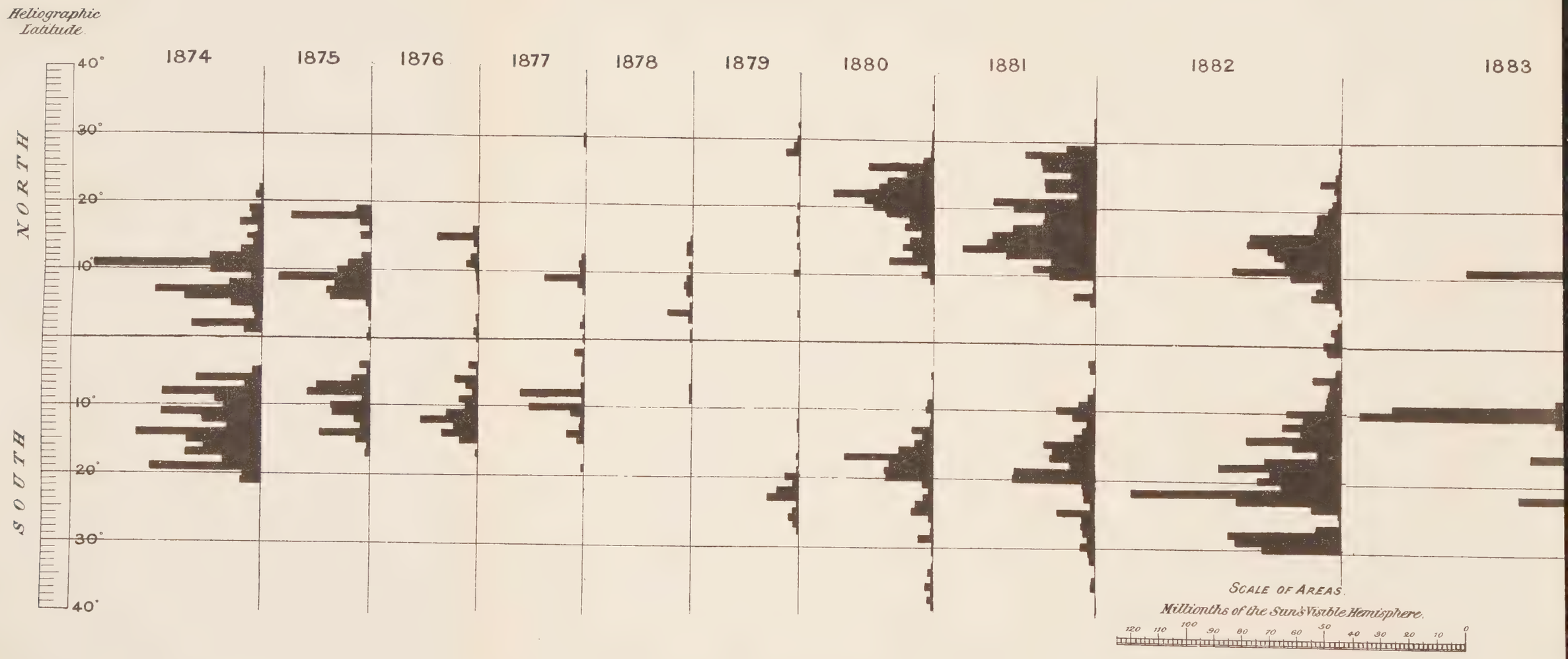
Royal Observatory, Greenwich:
1889 *November* 8.

Mean Daily Area of Sun-spots for each Degree of Solar Latitude for each Year from 1874 *to* 1888, *as measured on Photographs at the Royal Observatory, Greenwich.*

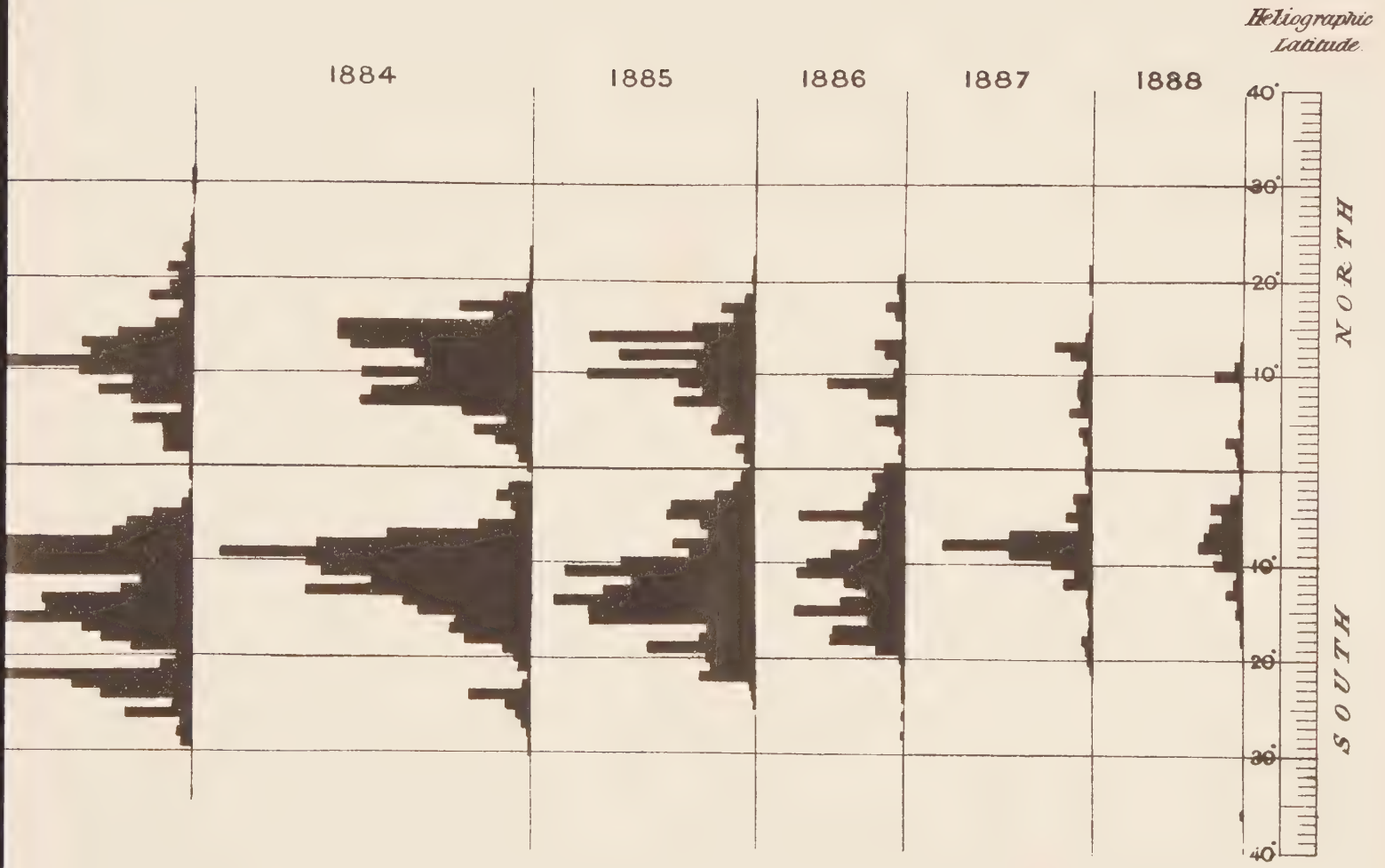
(*Communicated by the Astronomer Royal.*)

The diagram on Plate II. has been laid down in the following manner. The total areas of whole spots as expressed in millionths of the Sun's visible hemisphere have been taken out for each degree of solar latitude for each year, and divided by the number of days of observation, to give the mean daily area. In apportioning the different spots to their respective latitudes the following rule has been observed. If the heliographic latitude of the centre of any single spot, or group of spots when measured as one, showed °·5 or any higher figure in the decimal place, the entire area of the spot was taken as belonging to the next higher whole degree of latitude. If it showed °·4 or any

Mean Daily Area of Sun-Spots for each degree of Solar Latitude as measured on Photographs of the Sun, at the Royal Observatory, Gre



enwich, for the Years 1874 to 1888.



lower figure in the decimal place the entire area of the spot was taken as belonging to the degree of latitude indicated by the integral part of the number. Thus a spot at lat. 9°·5 was taken as wholly belonging to lat. 10°; but one at 9°·4 to lat. 9°.

The diagram shows in a marked manner the gradual decline in the distance from the equator of Sun-spots as the minimum is approached, and the sudden appearance of spots in high latitudes immediately after the minimum is passed and a new cycle has commenced.

Royal Observatory, Greenwich:
1889 *November* 8.

Note on Solar Spots in high South Latitudes.

By Rev. S. J. Perry, D.Sc., F.R.S.

It may be well to draw attention to the spots in high latitudes that have been visible on the solar surface during the last few months. These spots were all in the southern hemisphere, and with the exception of two groups were visible only for a short period. The following table comprises those recorded at Stonyhurst:—

Date.	S. Latitude.	Longitude.	Recorded duration.
	°	°	
1888, Dec. 30	36	195	1 day
1889, June 5	29	258	1 „
30	40	251	2 days
Aug. 2	21·3	155 to 165	36 „
Sept. 7	22	149·5 to 158·5	27 „
Oct. 8	28·5	9·5	1 day
10	25	24·5	1 „

The two large groups, whose latitude was not exceptionally high, form a narrow disturbed area extending over only 15° of longitude, and might almost be reckoned as a single disturbance, the first disappearing as the latter formed. The spot in latitude 40°, which was visible in England for two days, was also observed in North America. It is among the highest on record. The exceptional observations of Capocci, Peters, and Carrington all followed the minimum epoch of Sun-spots. The present increase in the number of spots in high latitudes agrees well with recorded observations of former minima.

Note to accompany a Drawing of the Milky Way. By Otto Boeddicker, Ph.D., Astronomer at the Earl of Rosse's Observatory at Birr Castle, Parsonstown.

(*Communicated by the Earl of Rosse.*)

The drawing of the Milky Way referred to was begun by me on October 24, 1884, and has occupied the greater part of my time and energy ever since. It was undertaken in the belief that an accurate representation of the galaxy, such as it appears to the naked eye, was an astronomical desideratum, and would be of some value for a variety of special investigations. In answer to a suggestion from your Secretary I propose now to give a short sketch of the history of the drawing.

First, I copied those maps of Argelander's *Uranometria Nova*, which should contain parts of the Milky Way, with the difference, however, that I indicated the stars by plain discs of different diameter only, in order to approach more nearly the actual appearance of the sky. Then, under exclusion of every trace of extraneous light, I examined the Milky Way, and as soon as I was satisfied that I had made out some feature, I turned on an incandescent lamp, and, by means of the stump, I inserted the detail observed in the map. This alternate seeing into darkness and on white paper (covered with black spots) proved a very great strain on the sight. Besides, as the eyes, after I had drawn the part observed, only very gradually regained their former sensitiveness, the work proceeded but slowly, three or four hours' drawing representing but a very small portion of it. As much as possible I drew the different sections only when they were near the meridian, in order to obtain the conditions most favourable for atmospheric transparency. This involved for the greater part of the Milky Way the necessity of my lying flat on my back (or nearly so) in the open air for hours together—a position which, especially on frosty nights, proved somewhat trying, for no amount of clothing was found sufficient to counteract the radiation of heat from the body.

The results were verified on consecutive nights, and further details added, so that a large number of nights was devoted to a single section. A further control was obtained by the overlapping of the sections, so that large portions of the Milky Way had to be drawn twice or even three times. This was in all cases done directly from the sky. In fact, the separate sections were never compared with each other until I had ceased to work at them. Next I constructed a large chart in stereographic projection down to 100° North Polar Distance, and inserted the parts of the Milky Way as furnished by the sections. This was required in order to deduce a true picture of the gradation of light in the Milky Way, or, in other words, a general uniform

standard of luminosity, for up to this stage of the work each section, being drawn independently, contained its own standard. This construction of a large chart was comparatively easy, since, in consequence of the overlapping of the sections, a *tertium comparationis* for the brightness of the different regions was readily found.

The large map having been drawn, three different methods of controlling the gradation of light were employed. First, the different spots and parts of the Milky Way were numbered, and written down directly from the sky in order of brightness, those parts which were equal in brilliancy being specially singled out. Next, I noticed repeatedly the order in which the different portions of the galaxy appeared from first twilight to complete darkness, and, finally, the order in which they disappeared with the rising Moon. Some special precautions against errors had to be taken during the two last series of observations, which, however, I have not now time to particularise.

I delayed the combination of the sections into a general chart as long as possible, as—in order to exclude the possibility of any preconceived idea as to the structure of the Milky Way on my part—I wanted to remain as long as possible in ignorance of its appearance *as a whole*. For the same reason I avoided carefully all previous pictures; the most important of these—Heis's in his *Atlas Cœlestis Novus*—I never even saw until I had finally given up drawing. Purposely I do not say "until my drawing was finished," for I found the difficulty of producing a picture of the Milky Way so extremely great, that even now, after having spent five years on it, I have not yet the sensation of having done all I could and should have done. Yet I think that my errors will be rather those of omission than of commission, as I did my very best not to put down anything which I did not perceive over and over again as I finally drew it. But, of course, the hand may not always be able to follow the eye, and I appeal, therefore, to other observers to verify or correct my drawing.

The last stage of the work consisted in the construction of the three enlarged sections covering the whole of the Milky Way, and the general chart as they are here exhibited. On the latter the parallels and meridians were not indicated, as I wanted it to contain nothing but what is actually seen in the sky. The stars in these maps were taken from the Catalogue of the *Uranometria Nova*.

It is not my object here to enter into a long discussion of my drawing. But I may perhaps direct attention to a few special points.

The fainter detail given in my map becomes best visible if examined at a distance of from five to ten feet. The physiological reason for this appears to be that the contrast between the faint nebulosity and the surrounding white ground is lessened, the larger an area of our retina is covered by the image of this nebulosity. It would be hard to decide how far this

detail follows any special law of grouping; yet the Milky Way seems to me pretty obviously to send out feelers (as it were) to nebulæ and clusters—for instance, to the nebula in *Andromeda*, and to *Præsepe* in *Cancer*. A similar tendency exists, perhaps, with regard to brighter stars. Further, I am struck with the tendency to duplication in Section III.*—a feature of which I only became aware when the general chart was constructed, and which is certainly not the outcome of any bias on my part. The larger stars seem to be surrounded by dark spaces. This cannot be altogether due to contrast, since in all these cases I employed special precautions—such as hiding the star by a small opaque object at a considerable distance from the eye—in order to get at the real appearance of the Milky Way in its immediate neighbourhood.

A comparison of my drawing with Heis's shows a striking absence of detail in the latter, no doubt owing to the fact that Heis did not devote sufficient time to it (that not being his main object), and also in consequence of his dividing the luminosity into five distinct degrees. This proceeding is not only contrary to nature, but becomes also a positive impediment in the way of any attempted imitation of it. Heis's drawing shows a broad region of faint luminosity surrounding the Milky Way proper. This I have not tried to imitate for two reasons. First, I am not sure that this luminosity is confined to the Milky Way. On the contrary, I perceive irregular patches of faint luminosity all over the sky—or, in other words, the background of the sky does not appear to me at all uniformly black. And, secondly, an attempt at drawing this luminosity would have thrown up, as it were, my scale of gradation to such an extent that pencil alone would have been insufficient to reproduce the most intense portions of the galaxy. In the same way all the lanes and rifts ought (probably with one or two exceptions) to be filled in with faint luminosity. I have tried to do this as much as possible, but may not have quite succeeded in rendering it conspicuous. Finally, I draw attention to the wisps of nebulous matter following rows of stars. It is not impossible that in some cases these wisps are due to the glare of the stars, or to irradiation on my retina; but, of course, according to my plan, I had to draw what I perceived. But it formed a part of my original programme to re-examine the Milky Way with a low-power telescope, in order to separate the optical from the physical luminosity. I now doubt much, however, whether I shall find time to do this, and I shall probably be obliged to leave this rather promising branch of the investigation to other observers.

In concluding these somewhat desultory remarks, I must not omit to state that one of the objects in exhibiting the drawing is to elicit opinions of astronomers as to the mode to be

* [Section III. represents that portion of the Milky Way which is situated in the constellations *Perseus*, *Camelopardus*, *Taurus*, *Auriga*, *Orion*, *Monoceros*, *Gemini*, and *Canis Minor*.—Eds.]

adopted for its reproduction, and also to ask whether a cheap reproduction of the star-charts alone (without the Milky Way) would be considered of any value for observatory use. I certainly found that the existence of such charts would have saved me a considerable amount of time and labour. May I, therefore, say that I should be very grateful for any general or special criticism, as well as for advice with regard to the best way to publish the maps?

A Discussion of Greenwich North Polar Distances of Polaris and other Stars, with reference to Corrections for Temperature and Humidity. By W. Grasett Thackeray.

(*Communicated by the Astronomer Royal.*)

The following paper is a continuation of one communicated to the Society last year, which will be published in vol. xlix. of the *Memoirs*, and is an endeavour to determine whether the discordances in the observed polar distances of *Polaris* arise from an imperfect correction for changes of temperature, or from the want of a correction for variations in the amount of humidity, or from some other cause.

The discordances here dealt with are the differences in the observed places of *Polaris* and *Polaris S.P.* as compared with the means of these observations grouped according to the readings of the exterior thermometer, or according to the value of humidity as given by the actual readings of the wet and dry bulb thermometer, taken from the photographic sheets, corresponding to the dates and times at which the observations of *Polaris* and *Polaris S.P.* were made.

The discordances for temperature depend on the observations made during the two periods, 1851–67, and 1877–84, and the discordances for humidity on the years 1877–84 only.

The following discordances, arranged according to temperature, are the result of a more careful discussion of the lower and higher temperatures, and an extension of the range of temperature in the latter direction, and represent errors of zenith distance.

Temperature	25°	30°·5	34°	38°	42°	46°	50°
1851–67 / 1877–84	+″·10$_{93}$	+″·16$_{111}$	+″·14$_{219}$	+″·18$_{393}$	+″·21$_{402}$	+″·06$_{456}$	+″·08$_{447}$
Temperature	54°	58°	62°	67°·5	72°·2	77°·0	83°·0
1851–67 / 1877–84	+″·04$_{366}$	−″·09$_{274}$	−″·16$_{274}$	−″·32$_{290}$	−″·45$_{130}$	−″·60$_{72}$	−″·49$_{21}$

Equating these residuals in the form $A + Bt$ = residual, where t = temperature, and A and B constants,

$$140\,A + 6983\,B = +258''.39,$$
$$6983\,A + 369721\,B = -\ 0''.97;$$
$$\text{Whence } A = -0''.721, \text{ and } B = +0''.01432;$$

and assuming the value of the refraction for *Polaris* as 45″, our correction to refraction becomes

$$(1) \qquad \frac{\text{Refraction}}{45}(0.0143\,t - 0.721);$$

and the corrections corresponding to the above temperatures for *Polaris* are

Correction	−′.36	−″.26	−″.23	−″.18	−′.12	−″.07	−″.01
Residual	−.26	−.10	−.09	00	+.09	−.01	+.09
Correction	+.05	+.10	+.17	+.24	+.31	+.38	+.47
Residual	+.09	+.01	+.01	−.08	−.14	−.22	−.02

The following discordances depend on the observations of *Polaris* and *Polaris S.P.* made during the years 1877–84, and the values of relative humidity for each observation were determined as follows:—The readings of the dry and wet bulb thermometers were taken from the meteorological records for the nearest hour to the time of meridian passage on each day of observation, and the value of the corresponding relative humidity (= "h") was then obtained from Glaisher's Hygrometrical Tables. The observations were then arranged according to the values of "h" for each year both above and below pole, and the differences between the mean of each of these groups and the mean annual value found, and these differences for each year, both above and below pole, were afterwards combined, and are as follows, representing errors of zenith distance.

Value of "*h*"	98	92	87	82	77	72
1877–84	$+''.21_{116}$	$+''.26_{139}$	$+''.24_{131}$	$+''.08_{123}$	$+''.08_{108}$	$+''.02_{98}$
Value of "*h*"	68	62	58	53	47	43
1877–84	$-''.14_{80}$	$-''.29_{106}$	$-''.31_{79}$	$-''.47_{50}$	$-''.66_{21}$	$-''.81_{13}$

Equating these residuals in the form of $A + Bh$ = residual, where h = humidity (saturation being equal to 100), we have

$$1043\,A + 80597\,B = -\ 5''.24,$$
$$80597\,A + 6442707\,B = -3959''.02.$$
$$\text{Whence } A = +1''.274, \text{ and } B = -0''.016558;$$

and our assumed correction for humidity becomes

$$(2) \qquad \frac{\text{Refraction}}{45}(+1\cdot27-0\cdot0166\,h);$$

and the corrections corresponding to the above humidities for *Polaris* are

Correction	$-''\cdot34$	$-''\cdot24$	$-''\cdot16$	$-''\cdot08$	$''00$	$+''\cdot09$
Residual	$-\cdot13$	$+\cdot02$	$+\cdot08$	00	$+\cdot08$	$+\cdot11$
Correction	$+\cdot15$	$+\cdot25$	$+\cdot32$	$+\cdot40$	$+\cdot50$	$+\cdot57$
Residual	$+\cdot01$	$-\cdot04$	$+\cdot01$	$-\cdot07$	$-\cdot16$	$-\cdot24$

In order to compare the values for "h" and "t," the observations of 1877–84 were arranged according to temperature, and the values of "h" corresponding to this arrangement also found.

Temperature	25°	30°	34°	38°	42°	46°	50°
1877–84	$+''\cdot28_{16}$	$+''\cdot25_{36}$	$+''\cdot08_{58}$	$+''\cdot20_{131}$	$+''\cdot25_{147}$	$+''\cdot13_{141}$	$+''\cdot18_{136}$
"h"	82	84	87	85	84	82	81
Temperature	54°	58°	62°	67°	72°	77°	83°
1877–84	$+''\cdot08_{109}$	$-''\cdot36_{88}$	$-''\cdot28_{68}$	$-''\cdot45_{99}$	$-''\cdot60_{40}$	$-''\cdot78_{20}$	$-''\cdot64_{8}$
"h"	76	70	66	64	58	55	47

and the corresponding residuals, after applying our assumed corrections for "t" (1) and "h" (2) are

(1)	$-''\cdot08$	$-''\cdot01$	$-''\cdot15$	$+''\cdot02$	$+''\cdot13$	$+''\cdot06$	$+''\cdot17$
(2)	$+\cdot20$	$+\cdot14$	$-\cdot08$	$+\cdot07$	$+\cdot14$	$+\cdot05$	$+\cdot12$
(1)	$+\cdot13$	$-\cdot26$	$-\cdot11$	$-\cdot21$	$-\cdot29$	$-\cdot40$	$-\cdot17$
(2)	$+\cdot10$	$-\cdot24$	$-\cdot09$	$-\cdot23$	$-\cdot26$	$-\cdot41$	$-\cdot14$

The errors of the Sun's tabular N.P.D. for each month in the years 1877–86, corrected to one system of R — D and Bessel's refractions, and the present adopted value of colatitude for Greenwich, viz. $38^\circ\ 31'\ 21''\cdot90$, and furthermore reduced to represent the refractions referred to the Standard Meteorological thermometer, have been carefully computed. The means were also taken of the Standard thermometers corresponding to each group of observations to enable us to obtain a value for "t."

To obtain the value of "h" the values of the dry and wet bulb thermometer were taken from the meteorological records for each day of observation, and the corresponding value of relative humidity ("h") was taken from Glaisher's tables, and the mean of each group taken.

	Jan.	Feb.	March.	April.	May.	June.
Tabular Errors 1877–86	+″·20	−″·20	−″·39	+″·02	+″·25	+″·24
Approx. Mean N.P.D.	111°	103°	92°	80°	72°	67°
„ Mean Refraction	190″	120″	80″	50″	40″	33″
	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Tabular Errors 1877–86	+″·58	+″·33	+″·19	+″·18	+″·04	−″·26
Approx. Mean N.P.D.	68°	76°	87°	99°	108½°	113°
„ Mean Refraction	34″	45″	65″	100″	160″	210″
Temperature	38°·5	44°·0	51°·5	55°·1	63°·0	77°·0
Humidity	75	74	65	61	55	54
Temperature	72°·6	71°·2	65°·0	54°·7	45°·8	39°·2
Humidity	54	57	62	69	73	78

The residuals, after applying the corrections for "t" (1) and "h" (2), corresponding to the above temperatures and humidities are

(1) +″·91 +″·03 −″·46 −″·03 +″·09 −″·06 +″·34 +″·03 −″·11 +″·08 +″·25 +″·44
(2) +·08 −·34 −·74 −·25 −·08 −·06 +·28 00 −·16 −·12 −·21 −·22

As these results were not satisfactory, and gave no assurance that either correction was an unmixed advantage, a table was made of the corrections for every 10° of zenith distance corresponding to what we assumed would be the extreme ranges of temperature and humidity for night observations, in order to see what sort of discordances might be expected to show themselves in the observations of the stars. The extreme temperatures were assumed to be 65° and 25°, and the extreme humidities 100 and 50. The following is the table:—

Zen. Dist.	Approx. Mean Refraction.	Temperature. 65°	Temperature. 25°	Relative Humidity. 100	Relative Humidity. 50
60°	100″	+0″·5	−0″·7	−0″·8	+0″·9
70	160	0·7	1·3	1·3	1·5
80	320	1·5	2·5	2·6	3·1
81	350	1·7	2·8	2·9	3·5
82	390	1·9	3·2	3·3	4·0
83	440	2·1	3·5	3·8	4·4
84	500	2·3	4·0	4·0	4·9
85	590	2·7	4·6	4·7	5·8
86	700	+3·2	−5·6	−5·6	+6·8

We then determined to see what effect these corrections would have on the observations of low southern stars, and the answer is apparently decisive. The observed places will allow of neither the one nor the other correction, but they show that the refractions of the Fundamenta give more satisfactory results than those of the Tabulæ, as also that any correction due to humidity is exceedingly small.

Taking the observations of low southern stars of Z.D. 82° 50′ and upwards for the years 1876–86, and correcting each daily result for R — D, colatitude and refraction, the same as for the mean places in the Greenwich 1880 Catalogue, and taking the assumed place, annual precession, and proper motion from the Cape 1880 Catalogue (Stone), we have called the difference between the observed places at Greenwich and the Cape, error of refraction at Greenwich. The mean Z.D. of all the stars used is $85°{\cdot}\frac{1}{2}$.

Taking the reading of the thermometer used in the reductions of each observation from the volume of Greenwich observations we have corrected these errors of refraction for our assumed law of correction for temperature (1) and arranged the errors in order of temperature, also giving the corrected errors for the corresponding humidities.

Taking the readings of the dry and wet bulb thermometers for the nearest half hour to the time of meridian passage of each star from the meteorological records we have found the relative humidities ("h") from these data, and corrected these errors of refraction according to our assumed law (2) for correction for humidity, and arranged the errors in order of humidity, also giving the corrected errors for the corresponding temperatures.

Finally we have diminished the log mean refractions of the Tabulæ for all observations above 85° Z.D. by ·00143 in order to show the errors of refraction as given by Bessel's Fundamenta, and the corresponding errors of refraction are given in each table.

TABLE I.

Temperature.		No. of Observations.		Error of Refraction (Tabulæ).		Error of Refraction (Tabulæ). Corrected for Temperature.		Error of Refraction (Tabulæ). Corrected for Humidity.		Error of Refraction. Fundamenta.	
31°5	35°3	11	31	+3″74	+2″65	+0″39	−0″57	+2″11	+0″16	+1″37	+0″68
37·4		20		+2·04		−1·10		−0·91		+0·30	
42·0	45·9	20	66	+3·00	+2·43	+0·29	+0·46	+1·16	+0·43	+1·38	+0·86
47·5		46		+2·21		+0·54		+0·11		+0·64	
52·7	55·5	49	95	+1·32	+1·53	+0·60	+1·63	−0·36	+0·33	−0·35	−0·18
56·8		32		+1·19		+1·49		−0·11		−0·34	
64·6		14		+2·96		+5·60		+3·72		+0·78	

TABLE II.

Humidity.		No. of Observations.		Error of Refraction (Tabulæ).		Error of Refraction (Tabulæ). Corrected for Humidity.		Error of Refraction (Tabulæ). Corrected for Temperature.		Error of Refraction. Fundamenta.	
97	93	13	58	+2″47	+2″09	−2″07	−1″70	+1″13	+0″63	+0″90	+0″28
92		45		+1·98		−1·64		+0·49		+0·10	
86	85	52	87	+1·76	+2·10	−0·28	+0·43	+0·27	+0·72	+0·23	+0·50
82		35		+2·73		+1·64		+1·77		+0·91	
75	73	36	45	+1·59	+1·74	+2·53	+3·05	+1·12	+1·67	−0·31	−0·13
65		9		+2·31		+5·14		+3·89		+0·60	

The mean error of refraction (Tabulæ) given by the stars below 85° Z.D. is $+1''\cdot00$ depending on 72 observations.

We now assume that the discordances are not connected with the correction for refraction, that they are still due to temperature, and probably closely connected with changes in the instrument itself, and that they vary as the sin Z.D. Our correction for temperature then becomes

$$(3)\quad \frac{\sin z}{\sin 38^\circ\cdot31'}(0''\cdot0143\,t - 0''\cdot721) = \sin z\,(0''\cdot0230\,t - 1''\cdot158),$$

and the following table represents the corrections to the low southern stars :—

Temperature.		No. of Observations.		Error of Refraction (Tabulæ).		Error of Refraction. Fundamenta.		Tabulæ Corrected. $(-1''\cdot158+0''\cdot0230\,t)\sin z$.		Fundamenta Corrected.	
°	°			″	″	″	″	″	″	″	″
31·5	35·3	11	31	+3·74	+2·65	+1·37	+0·68	+3·30	+2·28	+0·93	+0·32
37·4		20		+2·04		+0·30		+1·72		−0·02	
42·0	45·9	20	66	+3·00	+2·43	+1·38	+0·86	+2·80	+2·34	+1·18	+0·74
47·5		46		+2·21		+0·64		+2·12		+0·55	
52·7	55·5	49	95	+1·32	+1·53	−0·35	−0·18	+1·35	+1·62	−0·32	−0·08
56·8		32		+1·19		−0·34		+1·32		−0·21	
64·6		14		+2·96		+0·78		+3·26		+1·08	

The residuals, after applying this correction (3) to the errors of tabular N.P.D. of the Sun, as given above, are

January.	February.	March.	April.	May.	June.
+″·51	+″·03	−″·32	+″·02	+″·10	−″·20
July.	**August.**	**September.**	**October.**	**November.**	**December.**
+″·22	−″·06	−″·08	+″·18	−″·24	+″·06

The mean error for the year being now +″·01 instead of +″·10.

These results are more satisfactory, and seem to point to a probable explanation of R — D. The case seems to stand thus: here is a star constantly observed throughout the year, and the observations, when tabulated according to temperature, give marked discordances with a range of nearly 1″. First of all, assuming that these discordances were due to either a defective temperature correction, or to the want of a correction for humidity, it has been shown that the observations of low southern stars not only do not require such a correction, but apparently demonstrate that there is little or no fault to be found with the refractions in this respect; and, secondly, assuming that this temperature correction is also instrumental, and varies as sin Z.D., it is further shown that such a correction, applied to the observations of low southern stars, and to the tabular errors of the Sun, in both cases, gives satisfactory results. The same stars, observed both by direct view and also by reflexion from mercury, show large and varying discordances which are tabulated as R — D according to zenith distance, and are supposed to be applicable half to the R observation and half to the D observation, though there has never been any direct proof of the truth of this arrangement, and a correction is computed from a formula A+B sin z, when A and B are constants determined yearly from the observed R — D. Now these discordances in the direct observations of *Polaris* appear to also conform themselves to the same formula, and to be also applicable as corrections to other observations, and it would, therefore, be fair to assume that R−D was entirely an instrumental correction, and should contain a term depending on temperature. The importance of such a correction in the cases of the Sun and Moon, which are observed at very extreme temperatures in the course of the year, needs no demonstration.

The following table represents the mean Z.D.'s of each group of R — D stars for the year 1887, the mean thermometer reading used in the reductions, the correction required by our assumed temperature formula sin z (0·0460 t − 2·316) as applicable to R−D, and the difference between the observed value of R−D, and the value computed by the formula −″·06+1·365 sin z in use for that year.

The result of applying the assumed temperature correction is to diminish the sum of the squares of the residuals from 5″·56 to 4″·71.

Table of Assumed Temperature Correction to Groups of R − D, 1887.

Mean Z. D. South.	Mean Temp.	Assumed Temperature Correction.	Error of Ordinary formula.	Corrected Error.	Mean Z. D. South.	Mean Temp.	Assumed Temperature Correction.	Error of Ordinary Formula.	Corrected Error.
° ′	°	″	″	″	°	°	″	″	″
67 12	43·1	+·31	−1·13	−·82	+12·11	43·0	−·07	−·19	−·26
65 27	42·7	+·31	−0·95	−·64	19·50	46·8	−·05	+·02	−·03
63 19	42·4	+·32	+·28	+·60	24·16	46·4	−·08	−·02	−·10
62 21	46·7	+·14	−·01	+·13	27·31	45·7	−·09	+·14	+·05
59 4	45·5	+·18	+·23	+·41	31·1	45·0	−·12	+·36	+·24
55 43	50·5	·00	+·23	+·23	33·28	45·0	−·13	+·39	+·26
51 41	46·8	+·12	−·27	−·15	37·38	51·2	·00	−·02	−·02
47 30	39·6	+·33	−·02	+·32	40·58	46·4	−·13	−·24	−·37
41 18	48·4	+·07	−·17	−·10	43·38	43·0	−·23	−·01	−·24
35 28	45·8	+·11	−·11	·00	46·46	51·6	+·05	+·24	+·2
30 15	45·4	+·12	−·09	+·03	49·2	45·7	−·15	−·07	−·2
25 52	48·3	+·04	+·25	+·29	52·23	51·0	·00	+·05	+·0
21 26	44·3	+·10	+·12	+·22	56·23	48·2	−·08	−·41	−·4
16 12	42·8	+·06	+·55	+·61	60·48	42·1	−·33	−·66	−·9
13 13	50·9	·00	+·37	+·37	62·11	61·2	+·44	−·40	·0
− 9 59	45·3	+·04	−·46	−·42	65·5	34·5	−·68	+·86	+·18
					+67·13	52·4	+·08	−·62	−·54

The results we may sum up as follows :—The effect on refraction due to humidity, if any, is exceedingly small. A correction depending on temperature, and varying as sin z, will satisfy the discordances in the observations of *Polaris*, it will get rid of an annual variation, also apparently depending on temperature, in the tabular errors of the Sun; as far as it goes it will tend to bring in greater accordance the errors derived from low southern stars when arranged in order of temperature, and it will diminish the sum of the squares of the residuals of the R — D formula. Each of these results being a link in a chain partaking of the nature of circumstantial evidence.

Results of Double-Star Measures at Windsor, New South Wales, during the Years 1886, 1887, and 1888. By John Tebbutt.

This communication comprises all the double-star results obtained here during the years 1886, 1887, and 1888. All the measures were made with the eight-inch equatorial, except those of *α Centauri*, on July 27 and August 6, 1886, which were made with the $4\frac{1}{2}$-inch instrument. The column headed "Hour Angles" contains the hour-angles between which each set of measures was taken, and the last column gives the weight assigned from a consideration of the conditions under which the observations were made. 1 denotes an unusually bad condition, and 5 an unusually good one.

No.	Star.	Observed Magnitude.	Approx. Place for beginning of Year. R.A.	Dec. S.	Date of Obs.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Hour Angles.		Weight.
			h m	° ′		°		″			h m	h m	
1	*p* Eridani	...	1 36	56 46	1887·121	232·3	10	6·89	7	170	4 0 W	5 0 W	...
2	„	6, 6	„	„	1887·131	231·4	10	6·90	8	170	5 4 W	5 40 W	3
3	„	...	„	„	1887·734	230·7	10	...	...	230	4 45 E	4 24 E	...
4	„	...	„	„	1887·734	230·7	10	...	...	300			...
5	„	6, 6	„	„	1887·747	229·5	10	6·91	10	300	3 23 E	2 52 E	...
6	„	6, 6	„	„	1887·934	228·5	10	7·27	10	230	0 52 W	1 26 W	4
7	„	6, 6	„	„	1888·038	228·1	10	6·66	10	300	3 51 W	4 24 W	4
8	Lac. 2145	...	6 2	48 27	1887·104	26·3	10	2·07	7	170	1 0 E	0 21 E	3
9	„	8, 8¼	„	„	1887·205	24·0	10	...	...	170	2 11 W	3 14 W	3
10	„	...	„	„	1887·942	22·2	10	1·84	10	300	3 16 E	2 44 E	...
11	V Puppis	6½, 8	6 36	48 7	1888·288	...	...	13·39	5	...	4 11 W	4 25 W	...
12	Lac. 2640	...	7 2	59 1	1887·134	85·1	10	2·38	7	...	1 53 E	1 19 E	3
13	„	6½, 7½	„	„	1888·288	...	...	2·51	5	130	3 10 W	3 26 W	3
14	γ Piscis Vol.	4, 6	7 10	70 19	1888·288	...	...	13·28	5	170	2 8 W	2 42 W	4
15	„	...	„	„	1888·304	299·7	10	...	...	300	0 14 W	0 45 W	2
16	γ Argûs A.B.	...	8 6	47 0	1887·356	220·3	6	41·16	5	...	3 20 W	3 40 W	4
17	„ A.B.	2, 5	„	„	1888·301	...	...	41·77	5	130			3
18	„ A.C.	2, 7½	„	„	1888·301	...	...	62·32	5	130	1 13 W	2 12 W	3
19	„ A.D.	2, 8	„	„	1888·301	...	...	92·59	5	130			3

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			h m	° ′		°		″			h m	h m	
20	γ Argûs A.B.	2, 5	8 6	47 0	1888·301	220·4	5	...	...	140			3
21	„ A.C.	2, 7½	„	„	1888·301	151·2	5	...	...	140	2 12 W	3 0 W	3
22	„ A.D.	2, 8	„	„	1888·301	141·6	5	...	...	140			3
23	*h* 4087	8, 8¼	8 18	40 40	1887·345	298·6	10	1·85	5	170	3 33 W	5 14 W	3
24	„	...	„	„	1887·350	300·8	10	...	...	170	3 3 W	3 35 W	4
25	Lac. 3366	6, 9	8 26	44 21	1887·134	348·0	10	4·51	8	...	2 28 E	1 36 E	3
26	*h* 4306	7, 7	10 16	64 7	1887·134	138·4	10	1·89	3	...	2 54 E	2 19 E	3
27	Σ 1500	8½, 8¾	10 54	2 55	1887·131	311·7	10	1·71	5	170	3 1 E	2 20 E	3
28	*h* 4432	7, 8½	11 19	64 20	1888·320	298·6	10	...	...	300	1 20 E	1 1 E	4
29	„	8, 9	„	„	1888·323	...	...	2·23	8	170	2 12 E	1 55 E	4
30	*h* 4507	9, 10	12 8	44 16	1888·320	222·6	10	...	...	140	2 43 E	2 30 E	4
31	„	9, 10	„	„	1888·323	...	...	16·47	7	170	2 32 E	2 2 E	4
32	„	8, 9	„	„	1888·342	223·3	10	...	...	140	0 55 E	0 20 E	...
33	α Crucis	...	12 20	62 28	1887·104	115·8	10	5·19	6	170	3 52 E	3 27 E	3
34	„	1½, 1½	12 20	62 29	1888·320	120·4	10	...	...	230	1 49 E	1 26 E	4
35	„	...	„	„	1888·323	...	...	4·73	10	170	5 29 E	5 4 E	4
36	Lac. 5147	...	12 20	62 29	1888·323	...	...	89·96	5	170	4 53 E	4 38 E	4
37	„	1½, 5	„	„	1888·320	202·0	10	...	...	230	...	...	4
38	„	...	„	„	1888·323	...	...	89·87	5	170	4 38 E	4 26 E	4

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			h m	° ′		°		″			h m	h m	
39	δ Corvi	3½, 8	12 24	15 54	1888·208	214·9	5	24·11	5	130	3 20 E	2 45 E	3
40	γ Centauri	...	12 35	48 20	1887·580	359·6	8	...	...	300	4 24 W	4 40 W	3
41	„	4, 4	„	„	1887·586	358·5	10	1·76	7	300	3 4 W	3 30 W	3
42	„	4, 4	12 35	48 21	1888·219	0·4	10	1·56	5	170	3 41 E	3 10 E	4
43	„	4, 4	„	„	1888·320	...	...	1·80	10	170	3 21 E	3 4 E	3
44	„	...	„	„	1888·329	...	...	1·60	6	170	5 6 E	4 54 E	3
45	„	...	„	„	1888·329	359·3	10	1·79	6	...	4 47 E	4 21 E	3
46	„	...	„	„	1888·340	358·5	10	1·88	8	300	4 42 E	4 16 E	3
47	„	...	„	„	1888·605	...	...	2·73	8	130	4 16 W	4 30 W	2
48	„	...	„	„	1888·608	359·7	10	...	...	300	5 30 W	5 44 W	3
49	γ Virginis	4, 4	12 36	0 50	1887·386	155·5	10	5·61	10	300	1 49 E	1 10 E	3
50	„	4, 4	„	„	1887·386	155·5	10	5·69	10	300	1 7 W	1 55 W	2
51	„	...	„	„	1888·329	156·4	10	5·68	8	300	1 15 E	0 33 E	3
52	„	...	„	„	1888·635	153·3	10	5·86	8	300	2 40 W	3 15 W	4
53	β Muscæ	4, 4	12 39	67 30	1888·334	329·4	12	1·33	8	300	2 55 E	2 51 E	3
54	„	...	„	„	1888·340	329·2	10	1·18	5	...	2 47 E	2 19 E	3
55	Sydney$_2$, 213	8, 8	13 1	59 16	1888·334	26·1	10	0 7	...	300	2 11 E	1 59 E	3
56	Lac. 5632	7, 8½	13 35	53 59	1888·326	...	...	5·21	10	170	2 53 E	2 30 E	5
57	„	...	„	„	1888·329	163·6	10	5·23	5	300	3 23 E	2 48 E	4, 1

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			h m	° ′		°		″			h m	h m	
58	Sydney$_1$, 411	...	13 41	61 33	1888·323	...	...	12·27	8	170	2 50 E	2 12 E	4
59	*h* 4634	$8\frac{1}{2}$, 10	13 50	55 29	1888·326	...	...	12·19	10	170	3 55 E	3 28 E	4
60	„	$8\frac{1}{2}$, 10	„	„	1888·329	16·6	10	12·29	10	{230 / 140}	4 47 E	4 2 E	4
61	„	$8\frac{1}{2}$, $9\frac{1}{2}$	„	„	1888·340	13·7	10	12·65	6	140	3 9 E	2 38 E	4
62	„	...	„	„	1888·364	16·0	12	12·29	6	140	2 49 E	2 18 E	...
63	„	...	„	„	1888·605	...	...	12·68	7	130	3 56 W	4 18 W	4
64	„	8, 9	„	„	1888·608	14·4	10	12·27	5	140	3 24 W	3 54 W	3
65	*h* 4630	$8\frac{1}{2}$, $8\frac{1}{2}$	13 51	65 5	1888·342	314·1	10	4·18	7	{230 / 140}	3 43 E	3 14 E	...
66	α Centauri	1, 3	14 32	60 22	1886·567	200·8	10	15·30	10	...	1 23 E	0 48 E	4
67	„	1, 3	„	„	1886·567	202·9	10	15·48	10	...	0 33 W	1 5 W	3
68	„	1, 3	„	„	1886·594	199·9	10	14·84	10	180	2 18 E	1 46 E	3
69	„	1, 3	„	„	1886·594	203·8	10	15·22	10	180	...	1 47 W	3
70	„	...	„	„	1886·613	201·4	8	15·08	8	170	...	...	3
71	„	...	„	„	1886·613	202·0	5	15·65	5	170	...	1 48 W	1
72	„	...	„	„	1886·627	202·1	9	15·13	9	170	1 57 W	2 35 W	2
73	„	...	„	„	1886·646	201·2	5	14·90	5	170	5 52 W	6 21 W	2
74	„	...	„	„	1887·326	201·9	10	15·98	6	170	2 45 E	1 59 E	5
75	„	1, 2	„	„	1887·345	201·4	10	16·05	6	170	0 34 E	0 6 W	3
76	„	1, 2	„	„	1887·356	202·4	10	15·87	10	300	1 37 E	1 10 E	3
77	„	1, 2	„	„	1887·356	203·4	10	16·06	10	300	1 5 W	1 39 W	3

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			h m	° ′		°					h m	h m	
78	α Centauri	...	14 32	60 22	1887·479	202·3	10	...	...	300	1 13 W	1 27 W	4
79	,,	...	,,	,,	1887·482	...	...	16·35	10	300	0 6 W	0 35 W	3
80	,,	...	,,	,,	1887·575	202·1	10	16·36	7	230	3 34 W	4 0 W	2
81	,,	...	,,	,,	1887·597	202·0	8	...	...	230	1 38 E	1 24 E	...
82	,,	...	,,	,,	1887·597	202·4	10	16·20	10	230	1 1 E	0 36 E	...
83	,,	...	,,	,,	1887·646	202·9	10	...	...	300	0 34 E	0 22 E	4
84	,,	1, 2	,,	,,	1887·712	201·2	10	16·01	10	230	4 5 E	3 19 E	3
85	,,	1, 2	,,	,,	1887·712	202·4	10	16·10	10	230	0 7 W	0 47 W	4
86	,,	...	,,	,,	1887·712	203·1	10	16·11	10	230	4 50 W	5 29 W	4
87	,,	...	,,	,,	1887·734	202·5	10	16·42	10	230	4 30 E	3 55 E	3
88	,,	...	,,	,,	1887·734	201·7	10	...	...	230	2 52 E	2 41 E	3
89	,,	...	,,	,,	1887·734	202·6	10	16·28	10	230	0 13 W	0 54 W	3
90	,,	...	,,	,,	1887·734	201·6	12	...	...	230	2 38 W	2 55 W	3
91	,,	1, 3	,,	,,	1888·219	204·4	10	16 89	6	170	4 55 E	4 23 E	3
92	,,	...	,,	,,	1888·320	203·3	10	...	...	...	3 28 E	3 12 E	4
93	,,	...	,,	,,	1888·323	...	...	16·97	8	170	4 8 E	...	3
94	,,	1, 1½	,,	,,	1888·340	202·8	10	16·74	5	300	3 14 E	2 51 E	2
95	,,	...	,,	,,	1888·633	...	...	17·13	5	300	4 0 E	3 20 E	...
96	,,	...	,,	,,	1888·633	203·1	7	...	...	300	3 10 E	3 2 E	3
97	,,	...	,,	,,	1888·633	203·0	10	16 92	8	300	0 36 E	0 5 E	3
98	,,	...	,,	,,	1888·633	202·7	10	17·32	8	300	3 16 W	3 44 W	2

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			h m	° ′		°		″			h m	h m	
99	π Lupi	...	14 58	46 37	1888·654	86·3	10	1·50	5	300	3 33 W	3 58 W	3
100	Lac. 6477	7, 7	15 38	65 5	1887·356	153·4	10	2·36	8	300	1 46 E	1 21 E	3
101	,,	7, 7	,,	,,	1887·706	154·2	10	2·44	6	300	3 36 W	4 10 W	3
102	,,	7, 7	,,	,,	1888·652	148·2	10	2·19	1	300	1 22 W	1 46 W	2
103	,,	7, 7	,,	,,	1888·652	148·2	10	...	...	300	1 46 W	1 56 W	4
104	,,	7, 7	,,	,,	1888·654	150·5	10	2·37	5	300	2 24 W	2 44 W	3
105	ξ Lupi	6, 6½	15 50	33 38	1887·356	50·0	10	10·69	8	300	1 16 E	0 37 E	4
106	,,	6, 6½	,,	,,	1887·706	48·3	10	10·51	8	300	4 9 W	4 41 W	3
107	η Lupi	5, 9	15 53	38 4	1887·706	19·9	10	15·36	7	230	4 50 W	5 18 W	3
108	β Scorpii	...	15 59	19 30	1887·575	24·2	10	13·71	10	300	1 11 W	1 57 W	3
109	,,	3, 7	,,	,,	1887·597	24·9	10	13·82	10	300	1 43 E	1 14 E	5
110	Brisb. 5784	8, 8	16 33	60 42	1888·643	115·7	10	2·98	6	140	2 38 W	3 6 W	3
111	,,	8, 8	,,	,,	1888·649	115·3	10	2·71	5	140	0 59 W	1 24 W	4
112	Sydney$_2$, 287	8, 8	16 51	58 40	1888·649	129·8	10	2·89	5	140	2 0 W	2 22 W	4
113	36 Ophiuchi	6, 6	17 8	26 26	1887·531	199·1	10	4·64	8	300	1 26 E	0 32 E	5
114	,,	...	,,	,,	1887·701	196·6	10	4·59	8	300	3 12 W	3 41 W	3
115	Lac. 7267	7, 7½	17 19	45 44	1887·695	265·3	10	2·70	8	300	4 3 W	4 29 W	5
116	h 5027	9, 10	18 4	54 22	1887·742	97·2	12	...	...	140	2 50 W	3 17 W	...
117	,,	9, 10	,,	,,	1887·742	97·6	12	...	...	140	3 56 W	4 22 W	...
118	,,	9, 10	,,	,,	1887·767	97·4	10	11·84	4	140	3 47 W	4 25 W	...
119	κ Cor. Aust.	6, 7	18 26	38 48	1887·695	358·7	10	21·51	10	230	2 12 W	2 44 W	5

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			h m	° ′		°		″			h m	h m	
120	Lac. 7924	8, 8	18 53	63 57	1887·597	292·7	10	2·10	10	300	2 15 E	1 38 E	4
121	„	8, 8	„	„	1887·709	291·7	10	2·15	5	230	1 22 W	1 44 W	4
122	Brisb. 6556	5, 5	18 53	37 13	1887·767	282·2	10	12·71	7	140	3 49 W	4 16 W	5
123	„	7, 7	„	„	1888·643	280·8	8	12·76	5	230	1 32 E	1 9 E	3
124	γ Cor. Aust.	5½, 5½	18 59	37 13	1887·712	197·6	15	1·68	8	300	1 28 W	2 2 W	3
125	„	5½, 5½	„	„	1887·715	197·8	15	...	...	300	0 59 W	1 35 W	3
126	„	5½, 5½	„	„	1887·717	194·7	12	...	...	300	2 27 W	2 50 W	5
127	„	...	„	„	1887·767	194·7	10	...	...	300	4 16 W	4 27 W	4
128	„	...	„	„	1888·307	192·4	10	1·59	7	{300 / 170}	2 49 E	2 8 E	5
129	„	...	„	„	1888·633	189·6	10	1·73	5	300	3 31 E	3 9 E	4
130	„	...	„	„	1888·633	185·6	10	...	...	300	1 42 E	1 26 E	3
131	„	...	„	„	1888·638	189·4	12	...	...	300	1 40 E	1 26 E	5
132	„	6, 6	„	„	1888·643	186·8	10	1·82	7	300	2 7 E	1 47 E	3
133	„	...	„	„	1888·805	191·9	12	...	...	300	1 33 W	1 50 W	5
134	Lac. 8443	7½, 8	20 28	75 44	1887·586	16·0	10	17·92	10	230	2 37 E	2 6 E	3
135	Lac. 8550	7, 7	20 42	62 51	1887·643	94·7	10	2·94	8	{300 / 230}	1 28 E	0 48 E	4
136	Lac. 8687	8½, 8½	21 2	55 2	1887·709	124·8	12	3·08	5	230	1 45 E	1 12 E	...
137	θ Indi	6, 7½	21 12	53 55	1887·643	287·2	10	4·62	8	230	1 8 E	0 39 E	4
138	θ Gruis	5, 8	23 1	44 8	1887·717	22·1	10	2·33	8	300	3 5 E	2 34 E	5
	h 2167	7, 7½	23 1	51 18	1887·717	258·9	10	8·33	6	300	0 23 E	1 53 E	5

Remarks.

1. Stars exactly equal. 2. Impossible to decide which was the brighter. 5. North component the brighter.

6, 7. Components equal. 8. Components not quite equal. 10. South star the brighter. 14. Primary yellowish, companion blue. 17, 18, 19, 20, 21, 22. The distances were determined from the observed position-angles and differences of declination.

23. Distance observed with difficulty. Herschel's position-angle in 1837 = 146°·6, Hargrave's in 1879 = 308°·9.

24. Obviously a binary system. 25. Sydney measures of distance very discordant. 26. Probably identical with Stone 5639.

27. Distance difficult to observe. 30. Components very neatly defined. 31. Primary pink, companion blue.

34. Components equal. 35, 36, 38. Observations about sunset. 40, 42. Components equal.

43. Components equal, and observed without illumination. 44, 45. Observed without illumination.

46. Components equal; measures about sunset. 52. Components equal. 53. Elongated with a power of 140, just divided with 230, and well divided with 300. Components equal. 55. Components equal; distance estimated.

57. Images steady and well defined during position measures, but definition bad and images dancing during distance measures.

59, 60, 61. Primary white and companion blue. Certainly a binary. See Cape and Sydney measures.

65. The following and south component probably the brighter. 66, 68. Daylight observations.

74. Reduced to points of light by cloud, and well observed. 81, 82, 83. Observations before sunset.

84. 85. Distances determined from position-angles and differences of declination. 87, 88, 89, 90. Observed in daylight.

95. Distance determined from position-angle and difference of declination. 99. Components equal; easily divided with a power of 230, but distance difficult to determine. 101, 103. Components equal. 109. Observed in twilight.

110. A neat double; preceding component probably the brighter. Observed at Sydney as follows: 1871·604, mags. $6\frac{1}{2}$ and 7, P = 124°·1, D = 3″·80; 1880·630, mags. 10 and 10, P = 297°·8, D = 2″·82. 111, 112, 113. Components equal.

114. North component slightly the brighter. 116, 117. Companion very faint. 120. The haziness which characterised this star in 1885 not now seen. In 1885 the components were equal, but now the following star is the brighter.

121. Components equal and well defined. 122. The following component perhaps the brighter. 123. Components equal.

124. Components equal, and distance observations difficult. 125, 126, 127. Components equal. 132. Components equal and hazy.

136. Components equal; distance measures difficult. 137. Companion pale blue. 138. Primary white; companion pale blue.

Private Observatory, Windsor, N. S. Wales:
1889, *September* 25.

On the Proper Motion of the Double Star South 503.

By J. E. Gore.

Assuming that the change of position in the close pair is due to uniform rectilinear motion, I have computed the following formulæ :—

$$\rho^2 = 5{\cdot}76 + 0{\cdot}4225\,(t - 1885{\cdot}75)^2$$

$$\sec(\theta - 48^\circ{\cdot}04) = 0{\cdot}4166\rho.$$

The following is a comparison between the recorded measures and the positions computed from the above formulæ. The observed position-angles have been corrected for the effect of precession to 1880·0.

Epoch.	Observer.	θ_o	θ_c	$\theta_o - \theta_c$	ρ_o	ρ_c	$\rho_o - \rho_c$
1825·07	South	134°·41	133°·61	+0°·80	39″·94	39″·57	+0″·37
1873·93	Dembowski	120·13	120·69	−0·56	8·08	8·05	+0·03
1875·21	„	118·63	118·74	−0·11	7·07	7·26	−0·19
1875·88	„	117·52	117·52	0·0	6·72	6·85	−0·13
1881·18	Burnham	99·29	98·54	+0·75	3·58	3·82	−0·24
1882·16	„	92·39	91·24	+1·15	3·28	3·34	−0·06
1883·11	„	82·58	82·59	−0·01	2·90	2·95	−0·05
1887·039	Tarrant	30·36	31·09	−0·73	2·83	2·54	+0·29

The proper motion of the brighter star is, therefore, 0″·60 per annum in the direction of position-angle 138°·04.

Note on the Bright Line Spectra of R Andromedæ and R Cygni, and on the suspected Bright Lines in R Cassiopeiæ, and on the Spectrum of W Cygni. By the Rev. T. E. Espin.

On the night of September 25 the 17¼-inch was turned on *R Andromedæ*, and, although the star should have been at its maximum at the end of July, it was found to have a magnitude of about 6·5. On examining the spectrum the F line was found immediately to be bright. The brightness of this line was so extraordinary that it appeared to extend outside the spectrum. Another bright line, presumably D_3, was also observed, and near this place the spectrum seemed to consist of several very fine bright lines. The spectrum had the usual prominent bands of the third type, but far in the violet glimpses were caught of a very large and obscure band. Unfortunately the sky clouded up before the spectrum could be thoroughly examined. No other chance of examining the spectrum occurred until October 17. The star had now greatly faded, and was estimated at 7·8 mag.

It showed the usual third-type spectrum, and the F line was not certainly seen. At times it was suspected, but it had evidently decreased in brightness at a greater rate than the other parts of the spectrum.

R Cygni was examined on several nights, but the F line, if still bright, had nothing of the brilliancy which made the star such a remarkable object at the last maximum.

R Cassiopeiæ was examined on the night of September 25, and the magnitude was estimated at 7·3. It showed the usual third-type spectrum, but the bands are of remarkable size and intensity. Occasionally D_3 and the γ line of hydrogen were suspected bright, but not F.

W Cygni=Birm. 587=D.M.+44°·3877 was examined on the night of November 2 in strong moonlight. The usual third-type spectrum was seen, but no bright lines were suspected.

The Colours of Stars. By F. W. Levander.

In the course of certain investigations it became necessary to obtain a somewhat accurate estimate of the proportions of different colours exhibited by star-discs. As I am not aware of the existence of any statistics of a similar nature, the following table may possess some little interest for observers of coloured stars. It contains particulars of the tints, as described by various observers, of 4984 stars (arranged according to their magnitudes), which are to be found in the following catalogues :—

Chambers's Catalogue of Red Stars (*M. N.*, xlvii. 352) ...	504
Franks's M.S. Catalogue of 1730 Stars	1399
Herschel's Cape Observations	134
Tupman's Southern Stars (*M. N.*, xxxiii. 312)	91
Webb's Celestial Objects for Common Telescopes, 4th edition	2856

All observations in which any discordance appears have been rejected ; in some instances the want of agreement was so marked as to lead one to imagine that the important factors of aperture and kind of telescope used must be answerable for at least some of the differing statements. It is also a well-established fact—but one not always sufficiently attended to by telescopists—that the education of the colour-sense is much neglected, especially in the case of our own sex. To avoid prolixity many of the similar tints have been grouped together.

No attempt has been made to discriminate between magnitudes beyond mag. 8. The same scale of magnitudes has, unfortunately, not been adopted in the above catalogues, but the differences in mags. 1 to 8, according to the various scales in use, are so slight that they may be practically ignored for my present purpose without much disadvantage.

Magnitudes	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-	Totals.
Ashy	...	...	...	...	...	1	5	67	73
Blue	1	2	...	1	...	5	30	242	281
Crimson	...	...	...	...	...	...	...	1	1
Garnet	...	...	...	...	...	...	...	1	1
Green	...	...	...	1	4	2	7	25	39
Grey	...	...	...	...	2	3	2	28	35
Lilac	...	...	...	...	2	4	5	25	36
Orange	3	6	21	47	120	96	65	18	376
Purple	...	...	...	...	1	2	1	20	24
Red	2	2	4	8	40	63	107	194	420
Ruby	...	...	...	...	...	...	...	9	9
Scarlet	...	...	...	...	...	...	2	3	5
Violet	...	...	...	...	...	...	5	9	14
White	6	30	79	158	410	417	487	1041	2628
Yellow	8	22	79	129	265	250	154	135	1042
	20	62	183	344	844	843	870	1818	4984

University College School, W.C.:
1889, *October* 29.

Conjunction of Mars and Saturn, 1889 *September* 20. *Measurements taken at Arley Cottage, Mount Nugent, Cavan.* By Major S. H. Maxwell.

Lat. 53° 49′ 30″. Long. W. $0^h\ 29^m\ 13^s$.
Instrument, 6-inch refractor, by Grubb.
Micrometer, bifilar, by Grubb.

No.	G.M.T. h	m	s	Pos. Ang. °	Dist. ″	Ref. ″	Dist. ″	Par. ″	Cor. Dist. ″	
1	17	17	4	304·0	222·7	+0·5	223·2	+2·3	225·5	
2	17	19	34	304·5	218·4	,,	218·9	,,	221·2	
3	17	22	9	305·0	214·1	,,	214·6	,,	216·9	
4	17	31	41	305·8	203·5	,,	204·0	,,	206·3	
5	17	35	32	306·0	198·8	,,	199·3	,,	201·6	
6	17	41	51	307·0	191·0	,,	191·5	,,	193·8	
7	17	53	49	308·0	176·9	+0·4	177·3	,,	179·6	
8	17	57	37	309·0	171·0	,,	171·4	,,	173·7	
9	18	4	7	309·5	162·9	,,	163·3	,,	165·6	
10	18	7	56	310·2	157·6	+0·3	157·9	,,	160·2	
11	18	12	39	310·8	153·3	,,	153·6	,,	155·9	
12	18	18	47	312·0	145·4	,,	145·7	,,	148·0	
13	18	31	46	315·5	130·6	+0·2	130·8	,,	133·1	Saturn very faint.
14	18	41	56	318·5	120·0	,,	120·2	,,	122·5	,, barely visible.

Sky became too bright to see any more of either planet.

The measurements were taken on the outside limbs of both planets, and 9″·6 (*Mars*, 2″·3, *Saturn*, 7″·3) subtracted for semi-diameter.

Time was taken by watch compared before and after observations with chronometer, and the error of the latter taken by five sextant altitudes of Sun the same afternoon.

Each number represents a single setting of the position and distance wires, as clouds were so frequent that only occasional measurements were possible.

Observations of Mars and Saturn at their Conjunction, 1889 *September* 19, *made at the Royal Observatory, Greenwich.* By E. W. Maunder.

(*Communicated by the Astronomer Royal.*)

A careful watch was kept for the two planets from their rising, but it was not until 17^h G.M.T. that the clouds passed away from before them sufficiently for any observations to be made. The following differences of Right Ascension and North Polar Distance were then observed by means of the transit micrometer of the south-east equatorial; aperture 12·8 inches. The times of transit of the two planets over the first four of the nine galvanic wires were recorded on the chronograph, and the differences of N.P.D. of the planets measured by the declination micrometer. The observations were made with considerable difficulty, as the images throughout were ill-defined and unsteady, and *Saturn* was pale and faint, the background of the sky being bright throughout the observations. Indeed the Sun had risen before the last six transits were taken.

The centres of both planets were observed in every instance except the second transit, when the first limb of *Saturn* was observed in R.A., but the centre in N.P.D. This observation has been corrected for the semi-diameter of the planet. The observations have been all corrected for the differential effect of parallax and refraction, and in the last two columns they are all reduced to the same epoch, $17^h\ 30^m$ G.M.T. The last observation has been rejected in taking the mean, as *Saturn* was then so faint that it could only be seen with the greatest difficulty, and was continually lost to sight. No further observations could be made after this transit as *Saturn* was then quite invisible.

Mars.—Saturn.

No. of Obs.	G.M.T. of Observation.	Corr. for Par.	Corr. for Refrac.	Diff. in R.A. Corrected.	Corr. for Par.	Corr. for Refrac.	Diff. in N.P.D. Corrected.	Reduced to $17^h\ 30^m$ Diff. in R.A.	Diff. in N.P.D.
	h m s	s	s	s	″	″	′ ″	s	′ ″
1	17 9 6	−0·11	−0·04	−13·27	−1·96	−0·2	−2 10·1	−11·55	−2 0·9
2	17 13 3	−0·11	−0·04	−13·04	−1·96	−0.2	−2 7·2	−11·65	−1 59·8
3	17 23 2	−0·11	−0·03	−12·14	−1·94	−0·2	−2 5·4	−11·57	−2 2·3
4	17 27 3	−0·11	−0·03	−11·79	−1·93	−0·2	−2 2·9	−11·55	−2 1·6
5	17 29 3	−0·11	−0·03	−11·74	−1·93	−0·1	−2 1·0	−11·66	−2 0·6
6	17 31 4	−0·11	−0·03	−11·47	−1·92	−0·1	−1 59·9	−11·56	−2 0·3
7	17 33 6	−0·11	−0·02	−11·33	−1·92	−0·1	−1 58·8	−11·58	−2 0·1
8	17 35 3	−0·11	−0·02	−11·25	−1·92	−0·1	−1 58·0	−11·67	−2 0·3
9	17 37 2	−0·11	−0·02	−11·05	−1·92	−0·1	−1 57·4	−11·63	−2 0·5
10	17 39 3	−0·11	−0·02	−10·91	−1·91	−0·1	−1 57·0	−11·65	−2 1·0
11	17 41 3	−0·11	−0·02	−10·51	−1·91	−0·1	−1 56·6	−11·42	−2 1·4
12	17 43 3	−0·11	−0·02	−10·43	−1·91	−0·1	−1 56·5	−11·50	−2 2·2
13	17 45 1	−0·11	−0·02	−10·38	−1·90	−0·1	−1 55·8	−11·61	−2 2·4
14	17 47 4	−0·11	−0·02	−10·08	−1·90	−0·1	−1 55·1	−11·48	−2 2·6
15	17 51 2	−0·10	−0·02	− 9·85	−1·89	−0·1	−1 52·6	−11·58	−2 1·8
16	17 53 2	−0·10	−0·02	− 9·75	−1·89	−0·1	−1 50·7	−11·64	−2 0·8
17	17 55 2	−0·10	−0·02	− 9·50	−1·89	−0·1	−1 50·0	−11·56	−2 1·0
18	17 57 3	−0·10	−0·02	− 9·25	−1·88	−0·1	−1 47·0	−11·47	−1 58·9
19	17 59 4	−0·10	−0·02	−(9·65)	−1·88	−0·1	−(1 47·6)	−(12·04)	(−2 0·3)
							Mean	−11·574	−2 1·02

A positive eyepiece, power 130, was employed throughout.

Observations of the Occultation of Jupiter by the Moon, made at the Royal Observatory, Greenwich, 1889 August 7.

(*Communicated by the Astronomer Royal.*)

	Phenomenon.	Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation. h m s	Observer.
(*a*)	Disapp. First contact	S.E. Eq.	60	Dark	7 4 34·33	W. C.
(*b*)	,,	E. Eq.	70	,,	7 4 36·19	C.
	,,	Simms' No. 1	75	,,	7 4 28·97	S. D.
(*c*)	Last contact	S.E. Eq.	60	,,	7 6 5·33	W. C.
(*d*)	,,	E. Eq.	70	,,	7 6 10·92	C.
	,,	Simms' No. 1	75	,,	7 6 7·97	S. D.
(*e*)	Reapp. First contact	S. E. Eq.	200	Bright	7 59 56·37	W. C.
(*f*)	,,	E. Eq.	70	,,	7 59 54·59	C.

	Phenomenon.	Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation. h m s	Observer.
	First contact	Altaz.	100	Bright	7 59 54·49	J. P.
	„	Simms' No. 1	75	„	7 59 52·26	S. D.
(*g*)	Last contact	S.E. Eq.	200	„	8 1 39·09	W. C.
(*h*)	„	E. Eq.	70	„	8 1 34·81	C.
	„	Altaz.	100	„	8 1 37·70	J. P.
	„	Simms' No. 1	75	„	8 1 38·76	S. D.
	Reapp. Satellite II.	Lassell Refl.	280	„	8 6 15·17	H. T.
	„	E. Eq.	70	„	8 6 17·03	C.
	„	Simms' No. 1	75	„	8 6 18·78	S. D.
	Satellite IV.	Lassell Refl.	280	„	8 18 57·18	H. T.
	„	Simms' No. 1	75	„	8 20 31·85	S. D.

Notes.

(*a*) *Jupiter* faint and time uncertain to several seconds.

(*b*) Observation not easy owing to the faintness of *Jupiter*.

(*c*) Observation satisfactory.

(*d*) The dark limb of the Moon was very distinct as seen *on Jupiter*. This observation considered better than first contact.

(*e*) Probably a little late; *Jupiter* very much fainter than the Moon.

(*f*) Probably a little late; reappeared earlier than expected.

(*g*) Shortly before last contact there appeared to be a narrow dark band forming an outline to the Moon's limb on the much fainter disk of *Jupiter*. At about $8^h\ 1^m\ 37^s$ this band began to grow darker, and the first black separation between the limbs was seen at the time given for last contact, but only in the middle of the narrow band. Four seconds later the band had become black all over, and began to widen rapidly. The appearances were similar to the description of the black drop in the Transit of *Venus*.

(*h*) At the reappearance *Jupiter* appeared of a faint livid colour, belts very black. As the distance between the Moon and *Jupiter* increased the western limb gradually recovered its normal colour, which slowly spread over the disk, giving the appearance of emergence from a shadow, the belts gradually becoming of a coppery hue.

The clear aperture of the mirror of the Lassell Reflector is 24 inches, of the object-glass of the south-east equatorial 12·8 inches, of the east equatorial 6·7 inches, of the altazimuth $3\frac{3}{4}$ inches, of Simms' No. 1 (a detached telescope), 4 inches.

The initials W. C., H. T., C., J. P., and S. D. are those of Mr. Christie, Mr. Turner, Mr. Criswick, Mr. Power, and Mr. Dolman respectively.

Royal Observatory, Greenwich:
1889 *November* 12.

Occultation of the planet Jupiter and two Satellites by the Moon on August 7, 1889; observed at the Radcliffe Observatory, Oxford. By E. J. Stone, Esq., M.A., F.R.S., Radcliffe Observer.

The heliometer and 7-inch telescope were unavailable for the observation of the disappearance, from the obstruction of the view by trees and buildings. The reappearance, from the same cause, could not be observed with the heliometer.

I watched for the reappearance of *Jupiter* with the 7-inch instrument, power 125, but the first appearance was lost from passing cloud. The sky gradually cleared and I was able to see the rest of the phenomena without any interference from cloud. I saw nothing of the nature of distortion or shadow, although, as I had no clock or chronometer, my attention was particularly directed to these points.

The contrast of brightness between *Jupiter* and the Moon was very striking.

Owing to passing cloud the first contact at reappearance was not seen by the three observers stationed near the main building, but it was apparently well observed with the Barclay Equatorial, about 100 yards west.

The following are the times of contacts and remarks, given by the other observers:—

The planet Jupiter.

Disappearance, at Moon's dark limb.

	Local Sidereal Time.	G.M.T. of Observation.	Observer.
	h m s	h m s	
First contact	16 4 33·7	7 3 39·0	W.
,, ...	16 4 35·2	7 3 (40·5)	R.
,, ...	16 4 39·7	7 3 (45·0)	F. B.
4 dichotomised	16 5 8·7	7 4 14·0	W.
,, ...	16 5 15·2	7 4 20·4	R.
Last appearance	16 6 8·7	7 5 13·8	W.
,, ...	16 6 8·5	7 5 13·6	R.
,, ...	16 6 8·2	7 5 13·3	F. B.

Reappearance, at Moon's bright limb.

First contact	16 59 5·1	7 58 1·5	R.
4 projecting, say $\frac{1}{6}$ of diameter	16 59 30·7	7 58 27·1	W.
Dichotomised	16 59 46·7	7 58 43·0	W.
,, ...	16 59 55·1	7 58 51·4	R.
Last contact	17 0 56·7	7 59 52·8	W.
,, ...	17 0 51·6	7 59 47·7	R.

Jupiter's Satellites.

Reappearance, at Moon's bright limb.

		Local Sidereal Time.	G.M.T. of Observation.	Observer.
		h m s	h m s	
Satellite II.	First seen ...	17 5 26·6	8 4 22·0	R.
„	„ ...	17 5 40·7	8 4 36·1	W.
Satellite IV.	First seen ...	17 (19) 10·1	8 18 3·3	R.
„	„ ...	17 19 31·7	8 18 24·8	W.

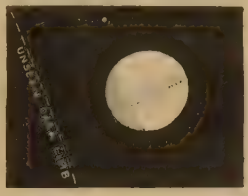
Clouds were frequently passing.

Observers' Remarks.

Mr. W. Wickham. Marlborough Telescope: aperture, $3\frac{1}{4}$-inch; power, 80.

Disappearance of *Jupiter.*

At $1\frac{1}{2}^m$ before first contact a shadow, like a crape veil, on the disc of *Jupiter* was noticed darkening that part of the planet nearest the Moon (similar to the "Earth-shine" on the new Moon), but extending over roughly $\frac{1}{6}$ of *Jupiter's* disc from the first limb.



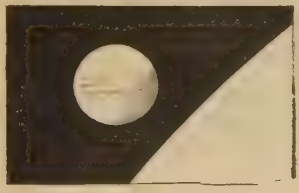
The time of "last appearance" considered very good, a tiny speck of light being last seen of the limb.

Reappearance of *Jupiter.*

First contact. Just lost in cloud, which after passing showed part of *Jupiter* projecting (say $\frac{1}{6}$ of its diameter).

Last contact. Good; sharp tangent, no black drop; the time noted is when a line of discontinuity was just shown between *Jupiter* and the Moon's limb.

The shadow noted at Disappearance was also seen at Reappearance on the following side of *Jupiter*, after the planet was quite free from the Moon, for about 2^m of time from last contact, it then ($8^h\ 2^m \pm$ G.M.T.) gradually paled, but was still visible for another 2^m or 3^m.



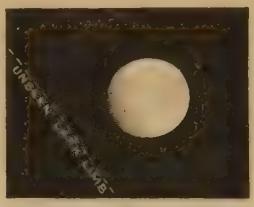
Reappearance of Satellite IV.

Very faint, may be 1^s in error.

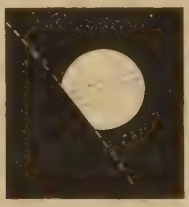
Mr. W. H. Robinson. Barclay Equatorial: aperture, 10-inch; power, 100.

Disappearance of *Jupiter.*

About 1^m before the first contact of *Jupiter* with the dark limb of the Moon I observed a change in the appearance of *Jupiter*, one quarter of the disc of the planet nearest the Moon's advancing limb being ill-defined and shaded, while the remaining $\frac{3}{4}$ of disc was sharply defined.



After watching this interference phenomenon for several seconds, I looked away in order to ascertain if it were caused by cloud, and, concluding that it was not, I resumed my observation at the telescope, when I found that I had just missed the first contact, the Moon's sharp edge having distinctly cut into *Jupiter*, thus:—



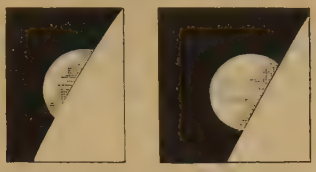
When the Moon's dark limb was well on *Jupiter* there appeared to be a bright line on *Jupiter* immediately contiguous to the Moon's limb.

Last contact. Good, almost instantaneous.

Reappearance of *Jupiter.*

First contact. Observation considered good. Well seen. The merest trace of *Jupiter's* limb visible. Very pale in comparison with Moon's bright limb.

As the Moon receded, an unmistakable shade (about $\frac{1}{4}$ of *Jupiter's* diameter) was seen projected on Jupiter, thus :—



This shaded band was parallel to the Moon's limb, and was visible during the whole of the transit of the Moon's limb over *Jupiter*.

Last contact. Half a second *before* the time given, *Jupiter* was "hanging on" the Moon.
Half a second *after* "last contact" *Jupiter* just free from Moon's limb.

Reappearance of *Jupiter's* Satellites.

Good observations.

Mr. F. A. Bellamy. Dollond Telescope: aperture, $3\frac{3}{4}$-inch; power, 80.

Disappearance of *Jupiter.*

First contact. Bad definition, no sharp edge; may be quite 5^s late.

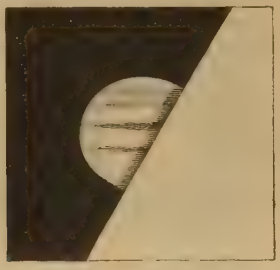
Last contact. Good observation. Limb very sharp. Quite satisfactory.

Radcliffe Observatory, Oxford:
1889, *November* 7.

Occultation of Jupiter by the Moon, 1889 August 7, observed at Forest Lodge, Maresfield. By Captain William Noble.

As the Sun was still above the horizon when the occultation began, and lighted a cirrous haze drifting over the Moon and *Jupiter*, the observation of disappearance was extremely difficult. The planet looked like the veriest ghost of itself, and had to be very steadily regarded for a defined limb to be seen at all. The actual observation of first contact was simply impossible; but by $16^h\ 11^m\ 1^s$ L.S.T. the Moon's limb had perceptibly encroached on *Jupiter*, who finally disappeared at $16^h\ 12^m\ 32^s{\cdot}6$ L.S.T. $=7^h\ 6^m\ 34^s{\cdot}9$ L.M.T., or $7^h\ 16^m\ 17^s{\cdot}8$ G.M.T. The interest of the occultation, however, culminated in the reappearance of the planet; the first glimpse of which I caught at $17^h\ 5^m\ 52^s{\cdot}4$ L.S.T., perhaps one or two seconds late. It had finally emerged, and, as nearly as I could judge, its limb and that of the Moon were tangent at $17^h\ 7^m\ 45^s{\cdot}4$ L.S.T.$=8^h\ 1^m\ 38^s{\cdot}68$ L.M.T., or

$8^h\ 1^m\ 21^s{\cdot}57$ G.M.T. As the planet appeared to emerge from behind the Moon the two equatorial belts were notably hard, dark, and sharp, and one towards *Jupiter's* south pole was also conspicuous. The most remarkable feature visible, though, I have endeavoured to depict in the accompanying sketch. It was a strongly marked shading, following the outline of the Moon's limb; and it gave a perfectly stereoscopic effect to the Moon and planet, the former being apparently much nearer to the eye. The detail on the planet's surface seemed generally to improve from its proximity to the Moon's limb, and presented that sharpness often incident on the passage of a light cloud or haze over the planet. *Jupiter* looked, generally, somewhat darker than the Moon, but this seemed rather an effect of colouring



than of obscuration. The shadow, of which the sketch gives a very fair idea, was, though, as I have previously said, by far the most remarkable feature observable. I employed a power of 135 (of course with a positive eye-piece) on the position micrometer of my 4·2 inch equatorial. The latitude of my Observatory is 51° 0′ 59″·8 north, and its longitude 17·11 seconds east of Greenwich.

The Late Occultation of Jupiter. By the Rev. S. J. Johnson, M.A.

The sky was everything that could be desired here on the evening of August 7 for the occultation of *Jupiter*. A higher power than 50 on $3\frac{1}{4}$-inch was not advisable. Contrary to what I had expected, the relative brightness of the planet seemed slightly fainter than that of the Moon on eye estimation. As the dark limb of the Moon was invisible, the impression produced on the eye of the observer, in an irresistible manner, was that of a rapid eclipse of a miniature Sun or Moon. At $7^h\ 0^m\ 24^s$ (time by sextant) there appeared an indentation on the circle of *Jupiter*. This was probably three or four seconds late. At $7^h\ 1^m\ 58^s$ the whole was submerged behind the dark limb of the Moon. First impression of the reappearance of *Jupiter* at $7^h\ 52^m\ 34^s$. Planet entirely clear of the Moon $7^h\ 54^m\ 20^s$. The Sun had set less than twenty minutes. The striking spectacle of all was the pale white-yellow colour of *Jupiter* close to the

bright golden disc of the Moon, when the planet was half out, and, in addition to this, the distinctness of the principal belts.

[The planet was not discernible in a good opera glass previous to immersion, but on the occasion of the last occultation in broad daylight, May 24, 1860, at $4\frac{1}{2}^h$, the disappearance could be seen without difficulty by means of an old ship glass, power 16, sheltered from the Sun's rays.]

Vicarage, Melplash, Dorset:
August 9.

Orbit of Comet III. of 1888. By Lieut.-Gen. J. F. Tennant, R.E., F.R.S.

This comet was discovered by Mr. Brooks on August 7, when it had already passed its perihelion seven days. The first accurate observation of it I have found is at Carleton College on the following day, but it is alone, and therefore I have not used it in my work, as it promised to complicate the deduction of the normal places. The comet was extensively observed till September 12, after which date the observations are fewer, and after October 10 I have only observations at Paris on two days, which I owe to the courtesy of Admiral Mouchez, Director of the Observatory, who sent me all the observations there in MS. I am also indebted to Mr. Plummer, of Orwell Park Observatory, for MS. observations, since published in the *Monthly Notices*.

I have examined all observations I could find in the *Astronomische Nachrichten*, Gould's *Journal*, *Monthly Notices*, *Comptes Rendus*, *Bulletin Astronomique*, and *Sidereal Messenger*. I have generally omitted to use all which depended on *Durchmusterung* stars; those of October 24 at Paris, however, are an exception, for I was unwilling to trust entirely to the observation of October 27 for a last normal place, though it would have agreed better with my final orbit than that I actually deduced.*

From the observations at Strassburg on August 10, at Kiel on September 1, and Dresden on September 23, I deduced a parabolic orbit.

$$T = \text{July } 31{\cdot}109783 \text{ G.M.T.}$$

$$\log q = 9{\cdot}9551934$$

$\Omega = 101^\circ\ 29'\ 45''{\cdot}0$	Ecliptic and equinox of 1888·0.		$\Omega' = 94^\circ\ 05'\ 42''{\cdot}38$	Equator and equinox of 1888·0.	
$\pi = 160\ 39\ 05{\cdot}1$			$\pi' = 177\ 37\ 07{\cdot}00$		
$i = 74\ 11\ 37{\cdot}5$			$i' = 70\ 57\ 41{\cdot}32$		

By comparing an orbit almost identical † with this with the

* The observations at Padua on August 12, and at Brussels on August 27, seem to be erroneously printed, and have been rejected.

† The difference arose from an error in copying a figure, and was very slight.

observations, and combining them, first into daily groups and then into groups of several days, I obtained, using only first powers of the time intervals in solving the equations of condition, the following eight normal places, to which were assigned weights nearly proportional to the number of observations used for them. That is, to Nos. 1, 2, and 3 each 2, to Nos. 4 and 5 each 1·5, to Nos. 6 and 7 each 1, and to No. 8 0·15.

No.	Observations.	No.	Date.	True α.	True δ.
1	Aug. 9–12	36	Aug. 10·5	157° 37′ 37″·0	+44° 50′ 45″·1
2	13–24	34	17·5	171 16 42·0	43 57 38·9
	25–31	34	28·5	191 55 49·2	39 08 06·6
4	Sept. 1–6	24	Sept. 4·5	203 19 24·2	34 23 28·3
5	7–17	20	12·5	214 19 08·7	28 13 18·1
6	23–30	14	26·5	229 11 32·8	17 33 25·0
7	Oct. 1–10	15	Oct. 5·5	236 38 59·5	11 34 55·6
8	24–27	2	25·5	249 42 53·1	1 22 57·4

Equations of condition having been formed for each observation, normal equations were formed and solved in the usual way, giving the following corrections to the elements :—

$$\delta T = -0^{d}\cdot014614 \pm 0\cdot014811$$
$$\delta \log q = -0\cdot0001320 \pm 0\cdot0000903$$
$$\delta e = -0\cdot0021225 \pm 0\cdot0007193$$
$$\delta \Omega' = +43''\cdot57 \pm 13\,04$$
$$\delta \pi' = -\ 4\cdot95 \pm 68\cdot24$$
$$\delta i' = +30\cdot77 \pm 11\cdot66$$

The separation of δT and $\delta \pi'$ in the elimination is very uncertain, and the probable errors of the elements mainly arise from the uncertainty of T which was left to the last.

The probable error of δe is about one-third of its amount, whence it would appear that the orbit is really elliptic, though the eccentricity is very uncertain. Had the comet been discovered a few days sooner, and observed about perihelion, we might have had doubts removed.

The resulting elements are :—

Perihelion passage, July 31, ·095169; July 31, $2^h\ 17^m\ 02^s\cdot6$.

$$\log q = 9\cdot9550614$$
$$e = 0\cdot9978775$$

$\Omega' = 94° 06′ 25″\cdot95$
$\pi' = 177\ 37\ 02\cdot05$
$i' = 70\ 58\ 12\cdot09$
} Equinox and equator of 1888·0.

Computing from these elements the places at the times of

the normals, we have the following values of observation-computation.

δ R.A.	+2″·3	−2″·3	−1″·8	−0″·8	−3″·1	+4″·8	+3″·8	−15″·8
Dec.	+3·6	−0·3	−3·9	−0·4	+1·9	+2·6	+3·4	+ 5·4

The probable error of one of the constants of the equations of condition of the weight 1 is found 3″·18, and on the whole the observations seem satisfactorily represented.

The ecliptic elements are finally:—

$$T = \text{July } 31^{d}\cdot0952 = \text{July } 31\ 2^{h}\ 17^{m}$$
$$\Omega = 101^{\circ}\ 30'\ 11''$$
$$\pi = 160\ 38\ 50$$
$$i = 74\ 12\ 23$$
$$\log q = 9\cdot9550614$$
$$e = 0\cdot9979$$

Brooks's Comet. By J. I. Plummer, M.A.

Some recent observations which I have made of the two portions of Brooks's Comet seem to point to even greater interest than the actual division of the comet may have caused. The only fragment of the main body which I have been able to see at Orwell Park is the intermediate one of the three illustrated in the *Astronomische Nachrichten*, No. 2922, from the Vienna observations. During the month of September I succeeded in making eight sets of comparisons between the main body and this fragment which show a gradual increase in the distance both in R.A. and declination, but the rate of movement of separation was distinctly slower than in the previous month. Later I succeeded in making four similar sets of comparisons between October 17 and October 24, at which times I found that the fragment had greatly diminished in lustre relatively to the main comet, and also that the differences of R.A. and declination had certainly lessened, indicating an actual motion of approach. I should be very glad to have this fact verified by other observers, and as it appears probable that after the present bright moonlight the light will be still less, I would suggest that the matter is of sufficient interest to induce the possessors of large telescopes to pay attention to this comet without delay. I would add that it would appear that the period at which the greatest divergence took place is that of perihelion passage, i.e. September 26. The observations to which I have referred will be published in due course.

1889, *November* 8.

Observations of Comet e 1889 (*Davidson*), *made at the Melbourne Observatory with the South Equatorial and Dark-field Micrometer. Observer: P. Baracchi.*

(*Communicated by R. L. J. Ellery, F.R.S., Government Astronomer.*)

Date.	Melbourne Mean Time.	Comet − Star. Δα	Comet − Star. ΔN.P.D.	No. of Meas.	Comet Apparent. α	Log ($p \times \Delta$).	Comet Apparent N.P.D.	Log ($p \times \Delta$).	Red. to App. Place.	Star α 1889·0.	Star. N.P.D. 1889·0.
1889	h m s	m s	′ ″		h m s		° ′ ″		s ″	h m s	° ′ ″
July 23	8 54 43·2	+5 23·88	−15 4·0	3	12 46 10·98	+9·698	122 27 35·7	+0·467	+0·37 +11·2	12 40 46·73	122 42 28·48 (*a*)
25	9 53 16·7	−3 15·39	− 2 27·9	1	13 11 9·06	+9·704	116 47 15·0	+0·603	+0·58 + 9·0	13 14 23·87	116 49 33·9 (*b*)
26	11 30 36·0	+8 6·10	− 8 58·8	2	13 23 8·26	+9·708	113 44 25·9	+0·726	+0·51 + 8·0	13 15 1·65	113 53 16·7 (*c*)
29	9 33 51·8	+2 38·93	− 4 19·9	5	13 52 15·94	+9·637	105 31 36·7	+0·645	+0·71 + 4·5	13 49 36·30	105 35 52·1 (*d*)
29	9 52 49·6	−6 49·39	−18 48·2	1	13 52 22·56	+9·654	105 29 30·2	+0·659	+0·77 + 4·3	13 59 11·18	105 48 14·1 (*e*)
30	7 21 31·6	−13 13·74	− 6 47·4	3	14 0 19·23	+9·363	103 5 6·7	+0·595	+0·84 + 3·2	14 13 32·13	103 11 50·9 (*f*)
Aug. 1	9 53 18·1	+1 7·19	+ 9 40·1	7	14 17 18·08	+9·631	97 44 39·8	+0·700	+0·81 + 1·0	14 16 10·08	97 34 58·7 (*g*)
2	9 16 26·1	+2 51·66	−10 13·7	5	14 24 27·24	+9·584	95 26 56·7	+0·704	+0·81 + 0·2	14 21 34·77	95 37 10·2 (*h*)
2 10	9 48·9	−0 30·23	+ 3 25·1	7	14 24 43·35	+9·640	95 21 56·3	+0·716	+0·83 0·0	14 25 12·75	95 18 31·2 (*i*)
18	6 59 46·9	+0 41·29	+ 2 17·7	10	15 40 21·69	+9·155	72 25 16·4	+0·861	+0·88 − 9·7	15 39 39·52	72 23 8·4 (*j*)

Authorities.—(*a*) Stone 7058. (*b*) $\frac{1}{3}\left(\text{Yarnall } 5515 + 2 \text{ Gould } \frac{\text{xiii.}}{528}\right)$ Stone 7314. (*d*) $\frac{1}{4}$ (Lal. 25596 + 3 [O. A. 13247]).

(*e*) Yarnall 5816. (*f*) Yarnall 5911. (*g*) Armagh 1668. (*h*) $\frac{1}{2}$ (Gr. 7 year Cat. 1864 + Grant 3577). (*i*) Yarnall 5990. (*j*) 26 *Serpentis*. Melbourne Transit Circle.

Remarks.

July 23.—☄ a bright object. Sharp stellar nucleus 5th or 6th mag. Tail south following more than 30′ long. Diameter at head 4′ or 5′. Easily visible to the naked eye. Bisections of the nucleus easy.

July 25.—Only one measure taken through a short break in the clouds. Same appearance as on July 23.

July 26.—Overcast in early evening. ☄ low, observed through thick haze. Bisections difficult.

July 29.—Clouds interfering. ☄ observed through occasional breaks. Bisections easy.

July 30.—Nucleus diffused. Bad definition. Bisections unsatisfactory. Comet a little fainter. Nucleus no brighter than 6th mag. Tail south following about 30′ long. Still easily visible to the naked eye.

August 1.—Same appearance as on July 30. Bisections easy.

August 2.—Same appearance. Good bisections. Still visible to the naked eye.

August 18.—☄ much fainter. Nucleus quite diffused. Elongated nebulosity south following, about 20′ long. Bisections satisfactory.

Parabolic Elements Computed from Observations of July 23, 26, *and* 29.

T 1889, July 19·28958 G.M.T.

φ 14° 7′ 33″
Ω 286 8 17 } M.E. 1889·0
i 66 1 53

$\log q$ 0·016927

$(O-C)\begin{cases} \cos\beta\,\Delta\lambda = -1''\cdot3 \\ \Delta\beta = +2''\,0 \end{cases}$

Observations of Comet e 1889 (*Davidson*), *made at Sydney Observatory with the* 11½*-inch Equatorial and Filar Micrometer.*

(*Communicated by H. C. Russell, B.A., F.R.S., Government Astronomer.*)

Date. 1889.	Sydney M.T. h m s	Star.	No. of Comp.	Comet - Star Δ R.A. m s	Comet - Star Δ N.P.D. ′ ″	Comet's Apparent R.A. h m s	Comet's Apparent N.P.D. ° ′ ″	Log. $p\Delta$ for R.A.	Log. $p\Delta$ for N.P.D.	Obs.
July 22	8 51 47	1	4	−4 30·86	−15 36·87	12 32 43·30	125 8 42·31	9·736	0 348	R.
22	10 37 55	2	2	+2 45·95	+ 8 1·57	12 33 42·10	124 57 18·29	9·777	0·616	Pk.
23	7 27 43	3	15	+4 23·73	− 2 26 76	12 45 10·87	122 40 12·22	9·590	0·069	R.
23	8 58 16	4	10	+1 17·32	−53 48·25	12 45 57·67	122 30 0·22	9·720	0·386	R.
24	7 40 0	5	12	+2 9·50	−19 35 17	12 57 54·91	119 54 39·56	9·585	0·192	R.
24	8 58 25	6	9	+1 49·44	+ 0 52·91	12 58 34·18	119 45 32·22	9·699	0·408	R.
24	8 58 25	7	9	−2 59·90	− 5 8·24	12 58 34·31	119 45 28·80	9·699	0·408	R.
26	9 0 33	8	1	+4 42·00	− 3 55·62	12 21 49·29	114 5 25 74	9·663	0·467	R.
26	9 0 33	9	1	+4 32·80	+ 0 46·87	13 21 49·40	114 5 25·88	9·663	0·467	R.
26	10 11 10	9	2	+5 4·24	− 7 43·17	13 22 20·84	113 56 55·84	9·718	0·578	R.
29	7 19 13	10	5	−3 34·32	+ 2 41·02	...	...	9·396	0 472	Pk.
29	7 19 13	11	5	−7 56·66	+ 1 38·28	13 51 15·27	105 49 57·22	9·396	0·472	Pk.
29	9 48 29	12	6	−9 0·19	− 6 55·61	13 52 11·86	105 32 47·54	9 669	0·595	R.
29	9 53 37	13	5	−6 54·00	+ 2 42·98	13 52 13·96	105 32 14·45	9·673	0·599	R.

The observers were R.=Russell; Pk.=Pollock. The reductions have been made by Mr. Pollock.

Mean Places for 1889·0 *of Comparison Stars.*

Star.	R.A.	Red. to App. Place.	N.P.D.	Red. to App. Place.	Authority.
	h m s	s	° ′ ″	″	
1	12 37 13·81	+0·35	125 24 7·02	+12·16	Argentine Gen. Cat. 17317.
2	12 30 55·84	+0·31	124 49 4·76	+11·96	Argentine Gen. Cat. 17162.
3	12 40 46·77	+0·37	122 42 27·74	+11·24	Stone 7058, Argent. Gen. Cat. 17403.
4	12 44 39·95	+0·40	123 23 37·01	+11·46	Stone 7084, Argent. Gen. Cat. 17473.
5	12 55 44·95	+0·46	120 14 4·38	+10·35	Stone 7174, Argent. Gen. Cat. 17725.
6	12 56 44·26	+0·48	119 44 29·11	+10·20	Argent. Gen. Cat. 17738.
7	13 1 33·71	+0·50	119 50 26·84	+10·20	Stone 7218, Argent. Gen. Cat. 17855.
8	13 17 6·71	+0·58	114 9 13·17	+ 8·19	Argent. Gen. Cat. 18215.
9	13 17 16·02	+0·58	114 4 31·00	+ 8·01	Argent. Gen. Cat. 18221.
10	...	...	...	...	Lalande 25716.
11	13 59 11·15	+0·78	105 48 14·54	+ 4·40	1st Radcliffe Cat. 3128, Yarnall 5816, 2nd Radcliffe Cat. 1349.
12	14 1 11·26	+0·79	105 39 38·83	+ 4·32	2nd Radcliffe Cat. 1357, Greenwich 7-year Cat. for 1860 1129, Yarnall 5832
13	13 59 7·18	+0·78	105 29 27·18	+ 4·29	Weisse's Bessel xiii. 1001.

Ephemerides of the Satellites of Saturn, 1889–90. By A. Marth. (*Concluded.*)

Approximate Differences of Right Ascension and Declination between the three outer Satellites and the centre of Saturn.

Greenwich Noon. 1890.	*Titan.*		*Hyperion.*		*Iapetus.*	
	α_6-A	δ_6-D	α_7-A	δ_7-D	α_8-A	δ_8-D
	s	″	s	″	s	″
Jan. 1	+10·27	+31·0	− 1·91	+29·9	−38·29	+31·7
2	+ 6·28	+32·8	− 6·64	+21·8	38·39	33·4
3	+ 1·23	+29·2	−10·83	+11·9	38·24	34·8
4	− 4·04	+20·8	−14·23	+ 1·0	37·84	36·1
5	− 8·69	+ 9·2	−16·66	−10·0	37·19	37·0
6	−12·04	− 4·0	−18·02	−20·5	−36·30	+37·7
7	−13·62	−16·7	−18·27	−29·8	35·18	38·2
8	−13·25	−27·0	−17·42	−37·4	33·83	38·3
9	−10·99	−33·6	−15·51	−42·7	32·26	38·2
10	− 7·07	−35·5	−12·64	−45·5	30·48	37·9
11	− 2·31	−32·4	− 8·93	−45·3	−28·50	+37·3
12	+ 2·90	−24·5	− 4·59	−42·0	26·34	36·4
13	+ 7·68	−12·9	+ 0·11	−35·5	24·01	35·3
14	+11·28	+ 0·8	+ 4·81	−25·9	21·53	34·0
15	+13·06	+14·4	+ 9·05	−13·7	18·91	32·5
16	+12·71	+25·8	+12·30	0·0	−16·16	+30·7
17	+10·22	+32·9	+14·08	+13·7	13·30	28·7
18	+ 6·01	+34·6	+14·05	+25·8	10·36	26·6
19	+ 0·79	+30·6	+12·15	+34·6	7·35	24·3
20	− 4·58	+21·6	+ 8·68	+39·0	4·28	21·9
21	− 9·24	+ 9·2	+ 4·14	+38·8	− 1·18	+19·4
22	−12·51	− 4·8	− 0·86	+34·3	+ 1·94	+16·7
23	−13·95	−18·1	− 5·81	+26·5	5·05	13·9
24	−13·38	−29·0	−10·27	+16·4	8·13	11·1
25	−10·90	−35·8	−13·96	+ 4·9	11·18	8·3
26	− 6·87	−37·6	−16·67	− 7·0	14·17	5·4
27	− 1·84	−34·1	−18·29	−18·6	+17·08	+ 2·5
28	+ 3·45	−25·6	−18·78	−29·1	19·89	− 0·3
29	+ 8·24	−13·1	−18·13	−37·9	22·59	3·1
30	+11·74	+ 1·4	−16·38	−44·5	25·16	5·9
31	+13·35	+15·9	−13·61	−48·5	27·58	8·6

Greenwich Noon. 1890.	*Titan.* α_5-A	*Titan.* δ_5-D	*Hyperion.* α_7-A	*Hyperion.* δ_7-D	*Iapetus.* α_8-A	*Iapetus.* δ_8-D
	s	″	s	″	s	″
Feb. 1	+12·78	+27·8	− 9·96	−49·3	+29·85	−11·2
2	+10·03	+35·1	− 5·62	−46·8	31·94	13 7
3	+ 5·61	+36·7	− 0·85	−40·7	33·83	16·1
4	+ 0·25	+32·1	+ 3 99	−31·3	35·52	18·3
5	− 5·17	+22·4	+ 8·44	−18·8	37·01	20·3
6	− 9·78	+ 9·1	+12·00	− 4·3	+38·27	−22·2
7	−12·92	− 5·7	+14·14	+10·8	39 29	23·9
8	−14·15	−19·8	+14·47	+24 6	40·07	25·4
9	−13·35	−31·1	+12 89	+35·2	40·60	26 7
10	−10·65	−38·1	+ 9 62	+41·4	40·88	27·8
11	− 6·43	−39·7	+ 5·16	+42·6	+40·91	−28·6
12	− 1·29	−35·8	+ 0 10	+39·0	40·67	29·2
13	+ 4·04	−26·3	− 4·97	+31·5	40·18	29·7
14	+ 8·76	−13·2	− 9·63	+21·2	39·43	29 9
15	+12·15	+ 2·2	−13·52	+ 9·2	38·42	29·8
16	+13·51	+17·4	−16·45	− 3·6	+37·16	−29·5
17	+12·66	+29·8	−18·29	−16 2	35·66	29·0
18	+ 9·70	+37·3	−18·98	−27·9	33·92	28·3
19	+ 5·11	+38·6	−18·52	−38·0	31·96	27·4
20	− 0·34	+33·5	−16·93	−45·9	29·78	26·3
21	− 5·74	+23·0	−14·30	−50·9	+27·41	−25·0
22	−10·24	+ 8 8	−10·75	−52·9	24·86	23 5
23	−13·20	− 6 8	− 6·49	−51·2	22·14	21·9
24	−14·21	−21·5	− 1·74	−45·8	19·26	20·1
25	−13·17	−33·2	+ 3·14	−36 6	16·25	18·2
26	−10·27	−40 3	+ 7·72	−24·0	+13·13	−16·2
27	− 5·91	−41·7	+11·49	− 8 9	9·92	14·1
28	− 0·70	−37·1	+13·92	+ 7·2	6·64	11 9
Mar. 1	+ 4·61	−27·1	+14·60	+22·5	+ 3·32	− 9·6
2	+ 9·21	−13·0	+13 35	+35·0	− 0 03	− 7·4
3	+12·36	+ 3·2	+10 34	+42·9	3·37	5·1
4	+13·51	+19 0	+ 6·04	+45 5	6·68	2·8
5	+12·43	+31·7	+ 1·05	+43 0	9·94	− 0·5
6	+ 9·26	+39·1	− 4 06	+36·1	13 13	+ 1·7
7	+ 4·54	+40·0	− 8·80	+25·9	16·23	3·9
8	− 0·93	+34 4	−12·84	+13 5	−19 21	+ 6·0
9	− 6·24	+23·1	−15 94	+ 0·1	22·04	8·0
10	−10·58	+ 8 3	17·96	−13·3	24·72	9·9

Greenwich Noon. 1890.	*Titan.* α_6-A	*Titan.* δ_6-D	*Hyperion.* α_7-A	*Hyperion.* δ_7-D	*Iapetus.* α_8-A	*Iapetus.* δ_8-D
	s	"	s	"	s	"
Mar. 11	−13·29	− 7·9	−18·84	−26·0	27·22	11·7
12	−14·10	−23·0	−18·56	−37·1	29·52	13·3
13	−12·85	−34·9	−17·17	−46·0	−31·62	+14·8
14	− 9·79	−41·9	−14·73	−52·2	33·49	16·1
15	− 5·34	−42·9	−11 36	−55·1	35·12	17·3
16	− 0·13	−37·8	− 7·23	−54·2	36·51	18·3
17	+ 5·09	−27·2	− 2·62	−49·7	37·64	19·2
18	+ 9·52	−12·4	+ 2·21	−41·0	−38·51	+19·9
19	+12·45	+ 4·3	+ 6·81	−28·7	39·12	20·4
20	+13·36	+20·4	+10·72	−13·5	39·46	20·7
21	+12·06	+33·1	+13·41	+ 3·2	39·54	20·9
22	+ 8·75	+40·3	+14·42	+19·5	39·35	20·9
23	+ 3·97	+40·8	+13·54	+33·3	−38·90	+20·7
24	− 1·45	+34·6	+10·88	+42·7	38·19	20·4
25	− 6·63	+22·8	+ 6·85	+46·8	37·24	19·9
26	−10·77	+ 7·4	+ 2·03	+45·5	36·05	19·3
27	−13·35	− 9·1	− 3·04	+39·4	34·62	18 5
28	−13·86	−24·2	− 7·76	+29·7	−32·97	+17·6
29	−12·43	−36·0	−11·87	+17·5	31·12	16·6
30	− 9·26	−42·7	−15·11	+ 4·0	29·08	15·5
31	− 4·78	−43·3	−17·29	− 9·8	26·87	14·3
Apr. 1	+ 0·37	−37·7	−18·36	−23·0	24·49	13·0
2	+ 5·45	−26·6	−18·31	−34·8	−21·96	+11·7
3	+ 9·68	−11·5	−17·16	−44·5	19·31	10·3
4	+12·39	+ 5·4	−14·97	−51·5	16·55	8·8
5	+13 09	+21·4	−11·86	−55·3	13 69	7·3
6	+11·63	+33·8	− 7·98	−55·5	10·77	5·8
7	+ 8·22	+40·7	− 3·55	−51·7	− 7·79	+ 4·3
8	+ 3·46	+40·7	+ 1·14	−43 9	4·77	2·8
9	− 1·87	+34·0	+ 5·71	−32·4	− 1·73	+ 1·2
10	− 6·88	+21·9	+ 9·69	−17·7	+ 1·31	− 0·3
11	−10·82	+ 6·4	+12·60	− 1·1	4·33	1 8
12	−13·12	−10·0	+13·96	+15·5	+ 7·32	− 3·3
13	−13·50	−25·0	+13·51	+30·2	10·25	4·7
14	−11·96	−36·4	+11·29	+40·8	13·11	6·0
15	− 8·74	−42·7	+ 7·63	+46·2	15·89	7·3
16	− 4·29	−42·9	+ 3·08	+46·2	18·56	8·6
17	+ 0·69	−36·9	− 1·80	+41·2	+20·12	− 9·8

Greenwich Noon. 1890.	*Titan.* α_6-A	*Titan.* δ_6-D	*Hyperion.* α_7-A	*Hyperion.* δ_7-D	*Iapetus.* α_8-A	*Iapetus.* δ_8-D
	s	"	s	"	s	"
Apr. 18	+ 5·67	−25·6	− 6·51	+32·3	23·54	10·9
19	+ 9·71	−10·4	−10·64	+20·8	25·81	11·9
20	+12·21	+ 6·3	−13·97	+ 7·7	27·93	12·9
21	+12·73	+22·0	−16·33	− 5·9	29·88	13·7
22	+11·16	+34·0	−17·62	−18·9	+31·65	−14·5
23	+ 7·73	+40·2	−17·84	−31·1	33·23	15·2
24	+ 3·03	+39·8	−16·98	−41·2	34·60	15·8
25	− 2·16	+32·9	−15·11	−48·8	35·76	16·3
26	− 6·99	+20·7	−12·31	−53·4	36·71	16·6
27	−10·73	+ 5·4	− 8·73	−54·5	+37·44	−16·9
28	−12·85	−10·7	− 4·57	−51·8	37·94	17·1
29	−13·08	−25·2	− 0·07	−45·2	38·22	17·2
30	−11·49	−36·1	+ 4·40	−34·8	38·26	17·2
May 1	− 8·27	−41·8	+ 8·44	−21·2	38·07	17·1
2	− 3·89	−41·6	+11·55	− 5·4	+37·65	−16 9
3	+ 1·02	−35·5	+13·28	+11·0	37·01	16·6
4	+ 5·77	−24·2	+13·31	+25·8	36·14	16·3
5	+ 9·62	− 9·2	+11·59	+37·2	35·05	15·8
6	+11·95	+ 7·0	+ 8·39	+43·8	33·75	15·3
7	+12·35	+22·1	+ 4·19	+45·1	+32·25	−14 6
8	+10·72	+33·4	− 0·46	+41·5	30·55	13·9
9	+ 7·31	+39·1	− 5·05	+33·8	28·66	13·1
10	+ 2·70	+38·3	− 9·20	+23·3	26·60	12·3
11	− 2·34	+31·2	−12·63	+11·1	24·37	11·4
12	− 6·99	+19·2	−15·17	− 1·9	22·00	10·4
13	−10·55	+ 4·3	−16·71	−14·7	+19·50	− 9·4
14	−12·53	−11·2	−17·22	−26·5	16·88	8·3
15	−12·70	−24·9	−16·70	−36·7	14·16	7·2
16	−11·06	−35·1	−15·20	−44·6	11·36	6·0
17	− 7·88	−40·3	−12·75	−49·7	8·49	4·8
18	− 3·60	−39·8	− 9·52	−51·7	5·58	3·6
19	+ 1·17	−33·6	− 5·66	−50·1	+ 2·65	2·4
20	+ 5·75	−22·5	− 1·40	−44·8	− 0·29	− 1·1
21	+ 9·45	− 8·0	+ 2·96	−36·0	3·22	+ 0·2
22	+11·65	+ 7·5	+ 7 01	−23·7	6·12	1·5
23	+11·97	+21·7	...	...	8·96	2·8
24	+10·32	+32·3	...	...	11·7	4·1

Greenwich Noon. 1890.	*Titan.* α_6-A	δ_6-D	*Hyperion.* α_7-A	δ_7-D	*Iapetus.* α_8-A	δ_8-D
	s	"			s	"
May 25	+ 6·97	+37·4	...	...	14·40	5·4
26	+ 2·47	+36·3	...	...	16·97	6·6
27	− 2·41	+29·3	...	...	−19·42	+ 7·8
28	− 6 90	+17·6	...	...	21·73	9·0
29	−10·32	+ 3·4	...	...	23·88	10·1
30	−12 20	−11·3	...	...	25·87	11·2
31	−12·31	−24·3	...	...	27·68	12·3
June 1	−10·69	−33·7	...	...	−29·30	+13·3
2	− 7·57	−38·3	...	...	30·71	14·3
3	− 3·41	−37·5	...	...	31·92	15·2
4	+ 1·23	−31·3	...	...	32·92	16·0
5	+ 5·66	−20·6	...	...	33·70	16·7
6	+ 9·23	− 6·9	...	...	−34·26	+17·4
7	+11·33	+ 7·8	...	...	34 60	18·0
8	+11·61	+21·1	...	...	34·72	18·5
9	+ 9·98	+30·8	...	...	34·61	19·0
10	+ 6·71	+35·3	...	...	34·29	19·3
11	+ 2·33	+34·0	...	...	−33·76	+19·6
12	− 2·41	+27·1	...	...	33·02	19·8
13	− 6·75	+15·9	...	...	32·08	19·8
14	−10·06	+ 2·5	...	...	30·95	19·8
15	−11·87	−11·3	...	...	29·63	19·7
16	−11·99	−23·3	...	...	−28·14	+19·5
17	−10 39	−31·9	...	...	26·49	19·2
18	− 7·36	−36·0	...	...	24·68	18·8
19	− 3·30	−34·9	...	...	22·74	18·3
20	+ 1·21	−28·9	...	...	20·67	17·7
21	+ 5·52	−18·7	...	...	−18·50	+17 0

Approximate Greenwich times of conjunctions of the satellites with the centre of the planet or of their passages in the direction of the minor axis of the ring.

1890.	h		h		h	
Jan. 1	11·1	Rh. w.	Jan. 2	19·5 Te. n.	Jan. 4	16·2 Mi. n.
	16·1	En. s.	3	6·4 Tit. n. 27″		16·8 Te. n.
	20·4	Mi. n.		11·2 Di. s.		20·0 Di. n.
	20 9	Te. s.		17·3 Rh. e.		20·4 Rh. n.
2	2·4	Di. n.		17·4 En. n.	5	14·9 Mi. n.
	8·5	En. n.		17·6 Mi. n.		15·5 Te. s.
	14·2	Rh. s.		18·2 Te. s.		18·7 En. s.
	19 0	Mi. n.	4	9·8 En. s.		23·5 Rh. w.

1890.

Jan.	6	4·9	Di. s.
		11·1	En. n.
		13·5	Mi. n.
		14·1	Te. n.
	7	2·6	Rh. s.
		12·1	Mi. n.
		12·8	Te. s.
		13 7	Di. n.
		20·0	En. n.
	8	5·6	Rh. e.
		10·7	Mi. n.
		11·4	Te. n.
		12·5	En. s.
		22·5	Di. s.
	9	8·7	Rh. n.
		10·1	Te. s.
	10	7·4	Di. n.
		8·7	Te. n.
		11·8	Rh. w.
		13 8	En. n.
	11	7·3	Te. s.
		11·6	Tit. s. 29′
		14·9	Rh. s.
		16·2	Di. s.
		17·9	Mi. s.
		22·7	En. n.
	12	6·0	Te. n.
		15·1	En. s.
		16·5	Mi. s.
		18·0	Rh. e.
	13	1·0	Di. n.
		4·6	Te. s.
		7·5	En. n.
		15·1	Mi. s.
		21 1	Rh. n.
	14	3·3	Te. n.
		9·9	Di. s.
		13·7	Mi. s.
		16·4	En. n.
	15	0·2	Rh. w.
		1·9	Te. s.
		8·8	En. s.
		12·3	Mi. s.
		18·7	Di. n.
	16	0·6	Te. n.
		3·3	Rh. s.
		10·9	Mi. s.
		17·7	En. s.
		23·2	Te. s.
	17	3·5	Di. s.
		6·3	Rh. e.
		9·5	Mi. s.
		10·2	En. n.
		20·8	Mi. n.
		21·9	Te. n.
	18	9·4	Rh. n.
		12·3	Di. n.
		19·0	En. n.
		19·5	Mi. n.
Jan.	18	20·5	Te. s.
	19	4·4	Tit. n. 29″
		11·5	En. s.
		12·5	Rh. w.
		18·1	Mi. n.
		19·2	Te. n.
		21·2	Di. s.
		23·1	Tit. & Iap. 0″
			? Occultation Feb.
	20	15·6	Rh. s.
		16·7	Mi. n.
		17·8	Te. s.
		20·4	En. s.
	21	6·0	Di. n.
		8·0	Iap. n. 19″
		12·8	En. n.
		15·3	Mi. n.
		16·5	Te. n.
		18·7	Rh. e.
	22	11·0	Rh. & Iap. 1″
		13·9	Mi. n.
		14·8	Di. s.
		15·1	Te. s.
		21·7	En. n.
		21·8	Rh. n.
	23	12·5	Mi. n.
		13·7	Te. n.
		14·1	En. s.
		23·7	Di. n.
	24	0·9	Rh. w.
		6·5	En. n.
		11·1	Mi. n.
		12·4	Te. s.
	25	3·9	Rh. s.
		8·5	Di. s.
		9·7	Mi. n.
		11·0	Te. n.
		15·4	En. n.
	26	7·0	Rh. e.
		7·9	En. s.
		8·4	Mi. n.
		9·7	Te. s.
		17·3	Di. n.
	27	8·3	Te. n.
		9·4	Tit. s. 31″
		10·1	Rh. n.
		16·7	En. s.
		18·3	Mi. s.
	28	2·1	Di. s.
		7·0	Te. s.
		9·2	En. n.
		13·2	Rh. w.
		16·9	Mi. s.
	29	5·6	Te. n.
		11·0	Di. n.
		15·5	Mi. s.
		16·3	Rh. s.
		18·1	En. n.
	30	4·3	Te. s.
Jan.	30	10·5	En. s.
		14·1	Mi. s.
		19·4	Rh. e.
		19·8	Di. s.
	31	2·9	Te. n.
		12·7	Mi. s.
		19·4	En. s.
		22·4	Rh. n.
Feb.	1	1·6	Te. s.
		4·6	Di. n.
		11·4	Mi. s.
		11·8	En. n.
	2	0·2	Te. n.
		1·5	Rh. w.
		10·0	Mi. s.
		13·4	Di. s.
		20·7	En. n.
		22·8	Te. s.
	3	4·6	Rh. s.
		13·1	En. s.
		21·5	Te. n.
		22·3	Di. n.
	4	2·2	Tit. n. 31″
		7·7	Rh. e.
		20·1	Te. s.
	5	7·1	Di. s.
		10·8	Rh. n.
		18·8	Te. n.
	6	13·8	Rh. w.
		15·9	Di. n.
		17·4	Te. s.
	7	14·3	Mi. n.
		15·7	En. s.
		16·1	Te. n.
		16·9	Rh. s.
	8	0·7	Di. s.
		8 2	En. n.
		13·0	Mi. n.
		14·7	Te. s.
		20·0	Rh. e.
	9	9·6	Di. n.
		11·6	Mi. n.
		13·4	Te. n.
		17·1	En. n.
		23·1	Rh. n.
	10	9·5	En. s.
		10·2	Mi. n.
		12 0	Te. s.
		18·4	Di. s.
	11	2·2	Rh. w.
		8·8	Mi. n.
		10·7	Te. n.
		18·4	En. s.
	12	3·2	Di. n.
		5·2	Rh. s.
		6·9	Tit. s. 34″
		9·3	Te. s.
		10·8	En. n.
		18 7	Mi. s.

1890. h
Feb. 13 7·9 Te. n.
8·3 Rh. e.
12·0 Di. s.
17·3 Mi. s.
19·7 En. n.
14 6·6 Te. s.
11·4 Rh. n.
12·1 En. s.
15·9 Mi. s.
20·9 Di. n.
15 5·2 Te. n.
14·5 Rh. w.
14·6 Mi. s.
21·0 En. s.
16 3·9 Te. s.
5·7 Di. s.
13·2 Mi. s.
13·4 En. n.
17·6 Rh. s.
19·8 ✶ 8^m precedes
$12^s{\cdot}7$ on parallel
17 2·5 Te. n.
11·8 Mi. s.
13·0 ✶ 8^ms. 78″
14·5 Di. n.
20·7 Rh. e.
18 1·2 Te. s.
10·4 Mi. s.
14·8 En. s.
23·3 Di. s.
23·7 Rh. n.
23·8 Te. n.
19 7·2 En. n.
9·0 Mi. s.
22·5 Te. s.
23·6 Tit. n. 34″
20 2·8 Rh. w.
7·6 Mi. s.
8·2 Di. n.
16·1 En. n.
21·1 Te. n.
21 5·9 Rh. s.
8·5 En. s.
17·0 Di. s.
17·5 Mi. n.
19·7 Te. s.
22 9·0 Rh. e.
16·2 Mi. n.
17·4 En. s.
18·4 Te. n.
23 1·8 Di. n.
9·8 En. n.
12·1 Rh. n.
14·8 Mi. n.
17·0 Te. s.
24 10·6 Di. s.
13·4 Mi. n.
15·1 Rh. w.
15·7 Te. n.

Feb. 24 h 18·7 En. n.
25 11·1 En. s.
12·0 Mi. n.
14·3 Te. s.
18·2 Rh. s.
19·5 Di. n.
26 10·6 Mi. n.
13·0 Te. n.
20·0 En. s.
21·3 Rh. e.
27 4·3 Di. s.
9·2 Mi. n.
11·6 Te. s.
12·4 En. n.
28 0·4 Rh. n.
4·4 Tit. s. 36″
7·8 Mi. n.
10·3 Te. n.
13·1 Di. n.
19·2 Mi. s.
20·8 Tit. ♂ Iap. 19″
Mar. 1 3·5 Rh. w.
8·9 Te. s.
12·3 Te. ♂ Iap. 3″
13·8 En. s.
17·8 Mi. s.
21·4 Iap. Transit
Ingr. 8″ s.
21·9 Di. s.
2 2·8 Iap. Transit
Egr. 6″ s.
6·5 Rh. s.
7·6 Te. n.
10·6 Iap. ♂ prec.
end of ring 4″ s.
12·6 Mi. ♂ Iap. 1″
13·4 Mi. ♂ prec.
end 4″
16·9 En. ♂ Iap. 1″
19·5 En. ♂ prec. end
6″
21·8 Te. ♂ Iap. 3″
3 6·2 Te. s.
6·8 Di. n.
9·6 Rh. e.
4 4·8 Te. n.
12·7 Rh. n.
15·6 Di. s.
5 3·5 Te. s.
15·8 Rh. w.
6 0·4 Di. n.
2·1 Te. n.
18·9 Rh. s.
7 0·8 Te. s.
9·3 Di. s.
21·1 Tit. n. 36″
22·0 Rh. e.
23·4 Te. n.
8 10·2 En. s.

Mar. 8 h 18·1 Di. n.
22·1 Te. s.
9 1·0 Rh. n.
18·0 Mi. n.
19·0 En. s.
20·7 Te. n.
10 2·9 Di. s.
4·1 Rh. w.
11·5 En. n.
16·6 Mi. n.
19·4 Te. s.
11 7·2 Rh. s.
11·7 Di. n.
15·2 Mi. n.
18·0 Te. n.
12 10·3 Rh. e.
12·8 En. s.
13·8 Mi. n.
16·7 Te. s.
20·6 Di. s.
13 5·2 En. n.
12·5 Mi. n.
13·4 Rh. n.
15·3 Te. n.
14 5·4 Di. n.
11·1 Mi. n.
14·0 Te. s.
14·1 En. n.
16·5 Rh. w.
15 6·5 En. s.
9·7 Mi. n.
12·6 Te. n.
14·2 Di. s.
19·5 Rh. s.
16 1·8 Tit. s. 37″
8·3 Mi. n.
11·3 Te. s.
15·4 En. s.
22·6 Rh. e.
23·0 Di. n.
17 6·9 Mi. n.
7·9 En. n.
9·9 Te. n.
18 1·7 Rh. n.
7·9 Di. s.
8·5 Te. s.
16·7 En. n.
16·8 Mi. s.
19 4·8 Rh. w.
7·2 Te. n.
9·2 En. s.
15·5 Mi. s.
16·7 Di. n.
20 5·8 Te. s.
7·9 Rh. s.
14·1 Mi. s.
18·1 En. s.
21 1·5 Di. s.
4·5 Te. n.

1890.	h				h				h
Mar. 21	10·5	En. n.	Apr.	5	2·7	Di. n.	Apr.	13	7·7	Di. n.
	11·0	Rh. e.			3·2	Rh. n.			14·8	Mi. n.
	12·7	Mi. s.			6·9	Te. n.			17·5	En. n.
22	3·1	Te. s.			12·2	En. n.			18·7	Te. s.
	10·4	Di. n.			14·6	Mi. s.		14	3·9	Rh. n.
	11·3	Mi. s.		6	5·5	Te. s.			9·9	En. s.
	14·1	Rh. n.			6·3	Rh. w.			13·4	Mi. n.
23	1·8	Te. n.			11·5	Di. s.			16·6	Di. s.
	9·9	Mi. s.			13·2	Mi. s.			17·4	Te. n.
	11·8	En. s.		7	4·2	Te. n.		15	7·0	Rh. w.
	17·1	Rh. w.			9·3	Rh. s.			12·0	Mi. n.
	18·9	Tit. n. 37″			11·8	Mi. s.			16·1	Te. s.
	19·2	Di. s.			13·5	En. s.		16	1·4	Di. n.
24	0·4	Te. s.			20·4	Di. n.			10·1	Rh. s.
	8·5	Mi. s.		8	2·8	Te. s.			10·7	Mi. n.
	20·2	Rh. s.			6·0	En. n.			11·3	En. n.
	23·1	Te. n.			7·9	Di. ☌ Iap. 3″			14·7	Te. n.
25	4·0	Di. n.			10·4	Mi. s.			22·1	Tit. s. 38″
	7·2	Mi. s.			12·4	Rh. e.		17	9·3	Mi. n.
	13·1	En. n.			16·9	Tit. n. 37″			10·2	Di. s.
	21·7	Te. s.		9	0·7	Mi. ☌ prec. end 4″			13·2	Rh. e.
	23·3	Rh. e.							13·4	Te. s.
26	5·6	En. s.			0·9	Mi ☌ Iap. 0″		18	7·9	Mi. n.
	5·8	Mi. s.			1·5	Te. n.			12·0	Te. n.
	12·9	Di. s.			1·7	Iap. ☌ prec. end 4″ n.			12·6	En. s.
	20·4	Te. n.							16·3	Rh. n.
27	2·4	Rh. n.			4·7	Iap. occulted by ring. Disapp. 3″ n.			19·1	Di. n.
	14·5	En. s.						19	10·7	Te. s.
	15·7	Mi. n.							19·4	Rh. w.
	19·0	Te. s.			5·2	Di. s.		20	3·9	Di. s.
	21·7	Di. n.			9·0	Mi. s.			9·3	Te. n.
28	5·5	Rh. w.			14·9	En. n.			13·9	En. n.
	6·9	En. n.			15·5	Rh. n.			16·4	Mi. s.
	14·3	Mi. n.			18·8	Iap. ? emerging from behind the ball in the space within the crape ring.			22·5	Rh. s.
	17·7	Te. n.						21	6·4	En. s.
29	6·5	Di. s.							8·0	Te. s.
	8·6	Rh. s.							12·8	Di. n.
	12·9	Mi. n.							15·1	Mi. s.
	15·8	En. n.			23·5	Iap. Reapp. from occultation by the ring 2″s.		22	1·6	Rh. e.
	16·3	Te. s.							6·6	Te. n.
30	8·2	En. s.							13·7	Mi. s.
	11·5	Mi. n.		10	0·1	Te. s.			15·3	En. s.
	11·7	Rh. e.			1·5	Iap. ☌ foll. end of ring 3″s.			21·6	Di. s.
	15·0	Te. n.						23	4·7	Rh. n.
	15·4	Di. n.			4·6	Te. ☌ Iap. 4″			5·3	Te. s.
31	10·2	Mi. n.			7·3	En. s.			7·7	En. n.
	13·6	Te. s.			7·6	Mi. s.			12·3	Mi. s.
	14·8	Rh. n.			14·1	Di. n.		24	3·9	Te. n.
	23·6	Tit. s. 38″			18·6	Rh. w.			6·5	Di. n.
Apr. 1	0·2	Di. s.			22·8	Te. n.			7·9	Rh. w.
	12·3	Te. n.		11	6·3	Mi. s.			10·9	Mi. s.
	17·9	Rh. w.			16·2	En. s.			15·3	Tit. n. 36″
2	9·0	Di. n.			21·4	Te. s.			16·6	En. n.
	10·9	Te. s.			21·7	Rh. s.		25	2·6	Te. s.
	21·0	Rh. s.			22·9	Di. s.			9·0	En. s.
3	9·6	Te. n.		12	8·6	En. n.			9·5	Mi. s.
	17·9	Di. s.			16·2	Mi. n.			11·0	Rh. s.
4	0·1	Rh. e.			20·1	Te. n.			15·3	Di. s.
	8·2	Te. s.		13	0·8	Rh. e.			16·2	Di. ? Ecl.

1890.	h				h			h
Apr. 26	1·2 Te. n.	May	10	5·1 Te. s.	May	21	15·5 Di. n.
	8·2 Mi. s.			10·8 En. s.		22	11·7 Te. n.
	14·1 Rh. e.			11·5 Mi. s.			13·7 Rh. s.
	23·9 Te. s.			14·1 Tit. n. 35″		23	0·3 Di. s.
27	0·2 Di. n.			16·6 Di. n.			1·3 Di. ? Ecl.
	17·2 Rh. n.		11	3·8 Te. n.			10·3 Te. s.
	22·6 Te. n.			6·5 Rh. n.			11·3 En. n.
28	9·0 Di. s.			10·1 Mi. s.			16·8 Rh. e.
	10·0 Di. ? Ecl.		12	1·5 Di. s.		24	9·0 Te. n.
	20·3 Rh. w.			2·4 Te. s.			9·2 Di. n.
	21·2 Te. s.			2·5 Di. ? Ecl.			19·9 Rh. n.
29	17·8 Di. n.			8·7 Mi. s.		25	7·6 Te. s.
	19·9 Te. n.			9·6 Rh. w.			18·0 Di. s.
	23·4 Rh. s.			12·2 En. n.			19·0 Di. ? Ecl.
30	18·5 Te. s.		13	1·1 Te. n.			23·0 Rh. w.
May 1	2·5 Rh. e.			10·3 Di. n.		26	6·3 Te. n.
	2·7 Di. s.			12·7 Rh. s.			13·4 Tit. n. 33″
	3·7 Di. ? Ecl.			23·7 Te. s.		27	2·2 Rh. s.
	12·6 Mi. n.		14	13·5 En. s.			2·9 Di. n.
	13·0 En. n.			15·8 Rh. e.			5·0 Te. s.
	17·2 Te. n.			19·2 Di. s.		28	3·6 Te. n.
2	5·6 Rh. n.			20·2 Di. ? Ecl.			5·3 Rh. e.
	11·2 Mi. n.			22·4 Te. n.			11·8 Di. s.
	11·5 Di. n.		15	19·0 Rh. n.			12·8 Di. ? Ecl.
	15·8 Te. s.			21·0 Te. s.		29	2·3 Te. s.
	20·5 Tit. s. 37″		16	4·0 Di. n.			8·4 Rh. n.
3	8·7 Rh. w.			19·7 Te. n.			20·6 Di. n.
	9·8 Mi. n.			22·1 Rh. w.		30	1·0 Te. n.
	14·4 En. s.		17	12·9 Di. s.			11·5 Rh. w.
	14·5 Te. n.			13·9 Di. ? Ecl.			23·6 Te. s.
	20·4 Di. s.			18·4 Te. s.		31	5·5 Di. s.
	21·4 Di. ? Ecl.		18	1·2 Rh. s.			6·5 Di. ? Ecl.
4	6·8 En. n.			14·5 Rh. ♂ Iap. 2″			14·7 Rh. s.
	8·4 Mi. n.			17·0 Te. n.			22·3 Te. n.
	11·8 Rh. s.			19·5 Tit. s. 37″	June	1	14·3 Di. n.
	13·2 Te. s.			21·7 Di. n.			17·8 Rh. e.
5	5·2 Di. n.		19	4·3 Rh. e.			20·9 Te. s.
	7·1 Mi. n.			8·6 En. n.		2	19·6 Te. n.
	11·8 Te. n.			10·0 Iap. ♂ foll. end of ring 4″ s.			20·9 Rh. n.
	14·9 Rh. e.						23·2 Di. s.
6	8·1 En. s.			14·3 Iap. Transit across ring. Ingress 3″ s.		3	0·2 Di. ? Ecl.
	10·5 Te. s.						18·3 Te. s.
	14·1 Di. s.						19·0 Tit. s. 33″
	15·1 Di. ? Ecl.			15·7 Te. s.		4	0·0 Rh. w.
	18·0 Rh. n.		20	2·5 Iap. Egress from ball 0″			8·0 Di. n.
7	9·1 Te. n.						16·9 Te. n.
	15·6 Mi. s.			6·6 Di. s.		5	3·2 Rh. s.
	17·0 En. s.			7·4 Rh. n.			15·6 Te. s.
	21·2 Rh. w.			7·6 Di. ? Ecl.			16·9 Di. s.
	22·9 Di. n.			8·4 Iap. Transit across ring. Egress 2″ n.			17·9 Di. ? Ecl.
8	7·8 Te. s.					6	6·3 Rh. e.
	9·5 En. n.						14·2 Te. n.
	14·2 Mi. s.			9·0 Iap. ♂ prec. end of ring. 2″ n.		7	1·8 Di. n.
9	0·3 Rh. s.						9·4 Rh. n.
	6·4 Te. n.			13·9 Rh. ♂ Iap. 11″			12·9 Te. s.
	7·8 Di. s.			14·3 Te. n.		8	10·6 Di. s.
	8·8 Di. ? Ecl.		21	10·0 En. s.			11·6 Di. ? Ecl.
	12·9 Mi. s.			10·6 Rh. w.			11·6 Te. n.
10	3·4 Rh. e.			13·0 Te. s.			12·5 Rh. w.

1890.	h		h		h
June 9	10·2	Te. s.	June 10 8·9	Te. n.	June 11 5·3 Di. ? Ecl.
	15·7	Rh. s.	18·8	Rh. e.	7·6 Te. s.
	19 5	Di. n.	11 4·3	Di. s.	13·0 Tit. n. 31″

By means of this list of conjunctions approximate values of the co-ordinates x and y of the five inner satellites may be easily found for any other time t with the help of the following little table, the argument of which is the interval τ between the time t and the time of the next preceding or following conjunction, the co-ordinates x and y being expressed in semi-diameters of the planet's equator.

τ	*Mimas.*		*Enceladus.*		*Tethys.*		*Dione.*		*Rhea.*	
h	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	x_5	y_5
0	0·0	0·5	0·0	0·7	0·0	0·9	0·0	1·1	0·0	1·6
1	0·9	0·5	0·8	0·7	0·7	0·9	0·6	1·1	0·5	1·6
2	1·7	0·5	1·5	0·6	1·4	0·8	1·2	1·1	1·0	1·6
3	2·3	0·4	2·2	0·6	2·0	0·8	1·8	1·1	1·5	1·5
4	2·8	0·2	2·8	0·5	2·6	0·7	2·4	1·0	2·0	1·5
5	3·1	0·1	3·3	0·4	3·2	0·7	2·9	1·0	2·5	1·5
6	3·1	0·1	3·7	0·3	3·7	0·6	3·5	0·9	3·0	1·5
7	2·9	0·2	3·9	0·2	4·1	0·5	4·0	0·9	3·5	1·4
8	2·5	0 3	4·0	0·0	4·5	0·4	4·4	0·8	4·0	1·4
9	1·8	0·4	4·0	0·1	4·7	0·3	4·8	0·7	4·5	1·4
10	1·1	0·5	3·8	0·2	4·9	0·2	5·2	0·6	4·9	1·3
11					5·0	0·0	5·6	0·5	5·3	1·3
12							5·8	0·5	5·7	1·2
14							6·2	0·3	6·5	1·1
16							6·4	0·0	7·1	0·9

As the latitudes of the inner satellites above the plane of the planet's equator, and also the true extent of the shadow-cone, are not known, it is uncertain when the cycles of the eclipses of the several satellites begin. In the case of *Tethys* the first eclipses are not observable from the Earth, since they take place while the satellite is hidden by the planet. But in the case of *Dione* the satellite remains outside the planet's disc, and it will be worth while to watch it about the times of the heliocentric conjunctions (*Di.? Ecl.*) given in the list, and to observe some of the earlier eclipses, taking care that the times of the observed disappearances and reappearances should refer to similar phases. Observers with powerful telescopes should look out whether, at the predicted times of "*Te.* n" in February and March, the shadow of *Tethys* can be discerned on the planet's disc. The conjunctions of *Dione* and *Rhea* with the centre of the planet are, during the present apparition of *Saturn*, most favourable for the determination of the orbital longitudes of these satellites, and it would

be a pity if the opportunities for observing them were neglected. By timely publication or communication of their observations of such conjunctions and of conjunctions of *Mimas*, *Enceladus*, and *Tethys*, with the ends of the ring, observers would have the satisfaction of rendering their contributions available for the proper prediction of the occurrences, which will make the observations of the satellites during the next apparitions of *Saturn* specially interesting.

A look over the ephemeris of *Iapetus* shows how favourable the conditions are for procuring the best direct data for fixing the elements of the satellite's orbit. In order to enable observers to prepare themselves the better for the proper observation of the conjunctions, the co-ordinates x, y of *Iapetus* referred to the axes of the ring are here added. By ascertaining, if feasible, the errors of the predicted places for preceding nights, observers may predict the times of the occurrences more closely than they are given in the list.

Co-ordinates of Iapetus referred to the Axes of the Ring.

0^h Gr. 1890.	x	y	0^h Gr.	x	y
	"	"		"	"
Jan. 19	−104·51	+35·82	Apr. 7	−112·14	+17·14
20	− 60·04	28·56	8	− 68·62	+10·62
21	− 15·10	21·11	9	− 24·85	+ 4·07
22	+ 30·03	13·52	10	+ 18·91	− 2·47
23	+ 75·09	+ 5·86	11	+ 62·43	− 8·96
			12	+105·42	−15·35
Feb. 28	+ 95·10	−22·60	May 18	+ 80·33	−12·79
Mar. 1	+ 47·11	−14·98	19	+ 38·04	− 6·70
	− 1·17	− 7·28	20	− 4·36	− 0·56
	− 49·40	+ 0·44	21	− 46·59	+ 5·55
4	− 97·22	+ 8·12	22	− 88·35	+11·62